The Role of Innovation Intermediaries in Developing Healthcare Innovation Ecosystems:

Value Co-Creation through Platforms

By

Chipo Nancy Ngongoni

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Supervisor: Professor Sara Susanna (Saartjie) Grobbelaar

Co-supervisor: Professor Cornelius Stephanus Lodewyk Schutte

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Declaration

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March 2021

Abstract

Sustainable development is the pathway to the future we want for all. It offers a framework to generate economic growth, achieve social justice, exercise environmental stewardship and strengthen governance — Ban Ki-moon

Creating sustainable agile innovative environments is a persistent challenge, which has been exacerbated by the COVID-19 global pandemic. The disruption in services has highlighted the need to foster innovation, build resilient health systems, operationalise technology banks and build more domestic capacity whilst harnessing global cooperation. These are the mandates of the 3rd, 9th and 17th Sustainable Development Goals (SDGs). One organisation cannot maintain and develop these systemic dynamics alone, hence ecosystems of actors ranging in structure and size are formed. These are the foundational precepts of this dissertation as it explores how to manage innovation ecosystems. Though such concerns are across diverse industries, this study was in healthcare. The aim was to inform under-resourced countries on how to ensure sustainability on projects often funded by foreign funders, which is rampant in the Global South.

This study contributed to the discourse of ecosystems research by developing an Ecosystem Evolution and Emergence Framework that assists in the management of the innovation ecosystem. Ecosystems research has mainly focussed on the structure of ecosystems and less attention has been devoted to the emergence of ecosystems. Thus, this study contributes to shedding some light on ecosystem emergence. The framework has two pillars for the innovation intermediary: outlining the key tasks to undertake at each ecosystem stage and the key aspects that are important to identify, monitor or cultivate in the ecosystem for the ecosystem actors. A constructivist perspective was used to better understand the relationship between innovation intermediation and innovation ecosystems. Conceptually, the framework development process was guided by Soft Systems Methodology with an emphasis on learning from the history of past projects addressing the same issues. These theoretical tools were deduced from established theories in innovation systems and complexity science embedded in a narrative explanation-Event Structure Analysis. This analysis was utilised through applying event colligation and displaying through Causal Loop Diagrams.

Empirically, a comparison of the emergence sequences from three healthcare innovation ecosystems was undertaken. These are the Maternal Alliance for Mobile Action (MAMA), MomConnect and the District Health Information System (DHIS2). The activities and functions were mapped in the study across the innovation ecosystem development stages of birth, expansion and self-renewal using the framework. This resulted in the identification of 39 core ecosystem events deemed leverage points – each with a myriad of activities. The evaluated framework culminated in five distinct leverage categories of structural, technological, social, knowledge and political leverage.

This is presented as an ecosystem management tool that enables: 1) building of innovation ecosystems; 2) facilitating improvement and sustainability of existing innovation ecosystems; and 3) providing the ecosystem manager with tools to address commonly experienced challenges. The tool's main aim is to provide guidelines on how ecosystems emerge and are governed. The systematic approach followed in the study lends itself to future development and expansion with various other computerised tools.

Opsomming

Die skep van volhoubare, veranderbare en innoverende omgewings is 'n voortdurende uitdaging wat vererger word deur die COVID-19 wêreldwye pandemie. Die ontwrigting in dienste het die noodsaaklikheid beklemtoon om innovasie te bevorder, veerkragtige gesondheidstelsels te bou, tegnologiebanke te operasionaliseer en meer plaaslike kapasiteit op te bou, terwyl wêreldwye samewerking benut word. Dit is die verskeie mandate van die 3de, 9de en 17de Doelwitte vir Volhoubare Ontwikkeling (SDG's). Een organisasie kan nie hierdie sistemiese dinamika alleen handhaaf en ontwikkel nie, daarom word ekosisteme van rolspelers gevorm wat wissel in struktuur en grootte. Dit is die grondbeginsels van hierdie proefskrif, aangesien dit ondersoek instel na die bestuur van innovasie-ekosisteme. Alhoewel soortgelyke kommer oor verskeie industrieë bestaan, was hierdie studie spesifiek in gesondheidsorg onderneem. Die doel was om lande met minder hulpbronne in te lig oor hoe om volhoubaarheid te verseker ten opsigte van projekte wat dikwels deur buitelandse befondsers gefinansier word en tiperend is van die Globale Suide.

Hierdie studie het bygedra tot die bespreking van ekosisteem-navorsing deur die ontwikkeling van 'n ekosisteem evolusie- en ontstaanraamwerk wat help met die bestuur van die innovasie-ekosisteem. Navorsing oor ekosisteme het hoofsaaklik gefokus op die struktuur van ekosisteme, en minder aandag is aan die ontstaan van ekosisteme gegee. Hierdie studie dra dus ook daartoe by om lig te werp op die ontstaan van ekosisteme. Die raamwerk het twee pilare vir die innovasie tussenganger: 'n uiteensetting van die belangrikste take wat in elke ekosisteemstadium uitgevoer moet word en die belangrikste aspekte wat nodig is om die ekosisteem rolspelers te identifiseer, te monitor of te kweek. 'n Konstruktivistiese perspektief is gebruik om die verband tussen innovasie-bemiddeling en innovasie-ekosisteme beter te verstaan. Konseptueel is die ontwikkelingsproses van die raamwerk gelei deur Sagte Stelselmetodologie, met die klem op die leer uit die geskiedenis van vorige projekte wat dieselfde kwessies aanspreek. Hierdie teoretiese instrumente is afgelei van gevestigde teorieë in innovasiestelsels en kompleksiteitswetenskap, ingebed in 'n narratiewe verduideliking - Gebeurtenisstruktuuranalise. Hierdie analise is gebruik deur die toepassing van gebeurteniskolligasie en vertoon deur oorsaaklike lusdiagramme.

Die onstaan van drie ekosisteme vir gesondheidsorginnovasie is empiries vergelyk. Die ekosisteme is die Maternal Alliance for Mobile Action (MAMA), MomConnect en die District Health Information System (DHIS2). Die aktiwiteite en funksies is vergelyk met die ontwikkelingstadia van ‘n innovasie-ekosisteem naamlik ontstaan, uitbreiding en selfvernuwing, deur gebruik te maak van die raamwerk. Dit het gelei tot die identifisering van 39 kern-ekosisteemgebeurtenisse wat as hefboompunte beskou word - elk met verskeie aktiwiteite. Die geëvalueerde raamwerk het opgeëindig met vyf verskillende hefboomkategorieë van strukturele, tegnologiese, sosiale, kennis- en politieke hefboomwerking.

Dit word vertoon as 'n ekosisteembestuursinstrument wat die volgende moontlik maak: 1) bou van innovasie-ekosisteme; 2) fasilitering vir die verbetering en volhoubaarheid van bestaande innovasie-ekosisteme; en 3) gereedskap vir die ekosisteembestuurder om uitdagings wat algemeen ervaar word, aan te pak. Die instrument se hoofdoel is om riglyne te gee oor hoe ekosisteme ontstaan en bestuur word. Die stelselmatige benadering wat in hierdie studie gevolg is, leen hom tot toekomstige ontwikkeling en uitbreiding met ander gerekenariseerde instrumente.

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To the implementers of DHIS2 who are working with minimal resources, hats off to you. A special thank you to Dr Tiwonge Davis Manda for being always available to assist me. Your kindness knows no bounds. *Zikomo!*

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Above all, to El Roi, *The God who sees me* wherever I am, here I stand - a testament of your faithfulness.

Gratitude is what it's all about and Grateful is what I am!!

What has been will be again,
What has been done will be done again.
There is nothing new under the sun. ***Ecclesiastes 1:9***

Dedication

To Liniah Ngongoni

…

Here I stand mummy

undefeated by something that has no breath

…

I wish you were here to see me as I evolve into who I am meant to be

THIS IS ME!!!

Create for me a space that I am free

Create for me a space that I can be

Create for me a space of liberty

-- ***Empress Chichi***

Here's to creating safe innovative spaces!!

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CAS	Complex Adaptive Systems
CLD	Causal Loop Diagram
DHIS2	District Health Information 2
EEEF	Ecosystem Evolution and Emergence Framework
ESA	Event Structure Analysis
FOSS	Free and Open Source Software
GIS	Global Innovation Systems
GT	Grounded Theory
HIS	Health Information System
HISP	Health Information Systems Project
I4ID	Innovation for Inclusive Development
MAMA	Mobile Alliance for Maternal Action
NORAD	Norwegian Agency for Development Cooperation
PATH	Program for Appropriate Technology in Health
PEPFAR	President's Emergency Plan for AIDS Relief
RIS	Regional Innovation Systems
SDG	Sustainable Development Goal
S-DL	Service-Dominant Logic
UiO	University of Oslo
UNICEF	The Global Fund, The United Nations Children's Fund

Chapter 1: Introduction

"*Remember, always, that everything you know, and everything everyone knows, is only a model. Get your model out there where it can be viewed. Invite others to challenge your assumptions and add their own.*" — Donella H. Meadows

This chapter introduces the background of the dissertation, problem analysis and the research gaps. Figure 1.1 depicts how the study was guided by the Soft Systems Methodology and where the chapter content fits in. The Soft Systems Methodology will be explained in detail in Chapter 2.

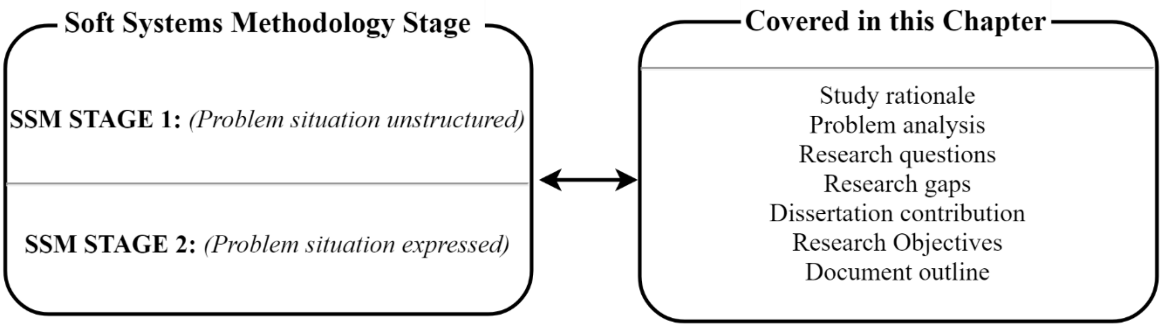

Figure 1.1: The Structure of Chapter 1 within the Context of the Soft Systems Methodology

1.1 Background of the Study

Collaborative design, diffusion and dissemination of innovation is something of an enigma. Hence, there has been an ongoing global call for countries to strengthen the innovation infrastructure and capacity of various industries. Underdeveloped and inefficient infrastructures limit access to basic services such as healthcare, energy and education (OECD, 2013). Balancing coopetition[1] amongst key stakeholders has become important as there is a shift in innovation from being product-centric to service and value-centric (Lusch & Nambisan, 2015). The strategic management of facilities, services and information has become a complex and multi-faceted process that involves a myriad of actors.

This phenomenon is apparent across industries, more so in healthcare where the innovation process is hampered by issues such as policies and procedures, possible security breaches, affordability and availability of resources (Hanlin & Andersen, 2016; Herselman & Botha, 2016; Omachonu & Einspruch, 2010). The quest of strengthening healthcare systems is a complex and multi-faceted issue as it is a reinforcing process and involves a wide range of actors. The complexity of the innovation process is exacerbated in the healthcare context where being innovative also means addressing issues such as patient privacy policies (Hanlin & Andersen, 2019; Omachonu & Einspruch, 2010; Zanello, Fu, Mohnen, *et al.*, 2016).

[1] Coopetition is the "act of cooperation between competing companies; businesses that engage in both competition and cooperation are said to be in coopetition" : https://www.investopedia.com/terms/c/coopetition.asp

Collaboration and co-creation between the ecosystem actors of service delivery initiatives is one way that has been identified to circumvent various challenges (Hanlin & Andersen, 2016).

1.2 Rationale of the Research

The healthcare industry is characterised by a high level of disruption (Hwang & Christensen, 2008). The industry is rampant with various technologies that go against various government mandates and yet do assist in providing and increasing access to service delivery. This has led to rethinking how interventions and strategies are undertaken holistically. To date the sector has experienced a proliferation of technological innovations aimed at improving the quality of care, diagnostic and treatment options and management of information systems (Hanlin & Andersen, 2016; Herselman & Botha, 2016; Omachonu & Einspruch, 2010). Developments such as digital health, precision medicine and diagnostic artificial intelligence, have led to healthcare actors experiencing a high level of cross-industry innovation (Phillips, Harrington & Srai, 2017). This has led to a high level of complexity in healthcare implementation and delivery due to the wide range of actors involved in the innovation process and a plethora of different protocols which results in fragmented solutions. Furthermore, the advancement and usage of various technologies is hampered by problems such as a lack of clear frameworks for technology integration or different protocols resulting in a variety of solutions for one problem, making management and sustainability resource-intensive and onerous. This is no surprise as the diffusion of innovation has always been a major challenge in firms, industries and across regions (Omachonu & Einspruch, 2010; Zanello *et al.*, 2016). Not only is the process complex, but business models and management structures have to be redefined to suit the ongoing and everchanging technological changes (Phillips *et al.*, 2017; Phillips, 2015).

This complexity can be attributed to the fact that the success and diffusion of healthcare innovation, like any other innovation, depends on interaction and collaboration between actors involved in the service delivery process (in this dissertation considered as ecosystem actors). This has thus resulted in a call for healthcare systems to embrace complexity and to look at the system holistically instead of being made up of individual entities. Therefore, enabling and jointly designing sustainable healthcare innovation ecosystems that attract, spur and cultivate innovation is of paramount importance (Adner, 2006; Autio & Thomas, 2014; Thomas & Autio, 2014; Verleye, 2015). One way of doing so is through the lens of healthcare innovation ecosystems (De Savigny & Adam, 2009; Iyawa, 2017; Phillips *et al.*, 2017).

Innovation ecosystems comprise of interconnected actors that are organised around a focal hub, firm or technology (Autio & Thomas, 2014; Gawer & Cusumano, 2014). One of the most prominent usage of the biological metaphor of ecosystems in innovation management was in the field of evolutionary economics where Rothschild exemplified the economy as an ecosystem (Rothschild, 1990). In 1993, Moore further developed this metaphor when he highlighted the interconnectedness of economic agents and their environment and how they rely on the collective health of the ecosystem for firm success and survival (Moore, 1993). The attractiveness of this metaphor has risen from its ability to highlight the interdependencies between organisations and their operating environments through specialisation, co-evolution and co-creation of value (Adner & Kapoor, 2010). This has spurred various branches of ecosystems research such as entrepreneurial ecosystems (Isenberg, 2011; Ngongoni &

Grobbelaar, 2017; Spigel, 2015a), software ecosystems (van den Berk, Jansen & Luinenburg, 2010), digital health innovation ecosystems (Iyawa, Herselman & Botha, 2016), digital service ecosystems (Thomas, 2013; Vargo, Wieland & Akaka, 2016), (technology) platform ecosystems (Gawer & Cusumano, 2014; Herman, Grobbelaar & Pistorius, 2018; Ngongoni, Grobbelaar & Schutte, 2018a; Pittaway & Autio, 2017) and innovation ecosystems (Autio & Thomas, 2014; Thomas & Autio, 2014).

The ecosystem construct consists of key characteristics around community heterogeneity, ecosystem outputs, participant interdependence, and distinctive governance (Thomas & Autio, 2020). These evolve around the context of the innovation, the innovation lifecycle and interactions between the users to create value (Autio & Thomas, 2014; Iyawa *et al.*, 2016; Rong, Lin, Shi, *et al.*, 2013; Thomas & Autio, 2012). Challenges in innovation ecosystems, particularly in healthcare platforms, come from a need to foster coordination and collaboration between various stakeholders from various disciplines that are responsible for propagating innovation for efficient patient care (Herselman & Botha, 2016; Iyawa *et al.*, 2016; Phillips *et al.*, 2017). This entails ensuring that the innovation ecosystem actors align with each other through the development of integrated health information systems to effectively manage information and data flows in healthcare ecosystem. Such complexity warrants further investigation and understanding.

Innovation ecosystems, if the metaphor is taken literally from natural ecosystems, should ideally function without any form of leadership or management. However, in the innovation ecosystem domain such systems often evolve around actors such as coordinators or platform leaders (formally or informally) that oversee the value creation process (Parker, Alstyne & Choudary, 2016; Smorodinskaya, Russell, Katukov, *et al.*, 2017; Thomas & Autio, 2020). With this observation in mind, this study starts from the premise that due to the high level of complexity from the implementation to application of innovation, some form of ecosystem management by an innovation intermediary is essential (Agogué, YströM & Le Masson, 2013; Autio & Thomas, 2014). For healthcare ecosystems which utilise platforms and handle extensive amounts of (often highly sensitive) data, this is of paramount importance.

Understanding how the ecosystem actors interact, create value and co-evolve with the ecosystem aides in understanding the value appropriation by the ecosystem (Autio & Thomas, 2014). Assessing the ecosystem construct in terms of activities around digital platforms in the healthcare sector is relatively important when it comes to explaining the emergence, implementation and sustainability of such ecosystems (Phillips *et al.*, 2017; Thomas & Autio, 2012). By focusing on a healthcare delivery platform, the main study objectives are to develop insights and a framework by which platform-centric healthcare innovation ecosystems can extract guidance on how to function more efficiently and effectively. Additionally, using systems thinking as a base for theory building for the innovation ecosystem construct and its structure assists in explaining various important dynamics of the ecosystem. These include the successful or unsuccessful dissemination of innovation, value creation and value appropriation for actors and users. In doing so, the study contributions add more insight on how platform-centric innovation ecosystems emerge. Of particular interest is the context of platforms that serve as innovation intermediaries in resource constrained (developing) countries as innovation ecosystems have mostly been conceptualised in light of developed countries (Iyawa *et al.*, 2016).

1.3 Problem Analysis

A health system consists of organisations, people and actions with the primary intent to promote, restore or maintain health (World Health Organization, 2007). With health systems being highly context specific no single set of best practices can describe them, but functional health systems do share certain characteristics (Hanlin & Andersen, 2016). The building blocks for a health system are a health workforce; research and information; medical products; vaccines and technologies; financing; health information system (s) (HIS) and good governance (World Health Organization, 2007). Health systems strengthening remains on the agenda globally, as a functional health system directly impacts health outcomes. To strengthen the health system, innovation that circumvents systemic exclusions created through poverty, unemployment, poor infrastructure and lack of access is important (Boyle, Levin, Hatefi, *et al.*, 2015; van der Merwe, Grobbelaar & Bam, 2020).

Innovation in healthcare is defined as a novel idea or set of behaviours, routines, and/or ways of working that involve a change in practice within a healthcare setting (Moullin, Sabater-Hernández, Fernandez-Llimos, *et al.*, 2015). Healthcare ecosystems participants need to transcend complexity and look at the system holistically instead of individual entities in the system (De Savigny & Adam, 2009). Healthcare interventions and innovations are costly, and time consuming to design and implement. Moreover, there are elements of equity and inclusion to consider when looking at healthcare innovations (Hanlin & Andersen, 2016; van der Merwe *et al.*, 2020).

There are various interconnected flows of knowledge, power and different types of innovations amongst a network of actors. These contribute to integrated healthcare which affects the wellbeing of society and the systemic policies that are developed. Thus, the orchestration (*managing and governing*) of ecosystems may reduce the risks aligned with redundant and silo technologies where healthcare ecosystem implementers must be proactive and create systems that evolve with such unpredictable dynamics. Healthcare innovation has been spurred through a push for funding projects that prioritise the Sustainable Development Goals (SDGs) (Gupta & Vegelin, 2016; UN, 2016).

Hanlin and Andersen (2016) noted from a review of health systems innovation research in Africa, that the majority of the discussion continues to be on the need for new or improved health technologies but less attention has been given to organisational, process and social innovations. They advocate that such innovations are especially what is needed when it comes to making healthcare systems function effectively. Social innovations are key to strengthening health systems where a mix of different forms of learning and knowledge flows occur across different types of innovation. So instead of focussing on just supple or demand the innovations are problem driven and respond to the needs of the various markets. This is depicted in Figure 1.2 (Hanlin & Andersen, 2016, 2019).

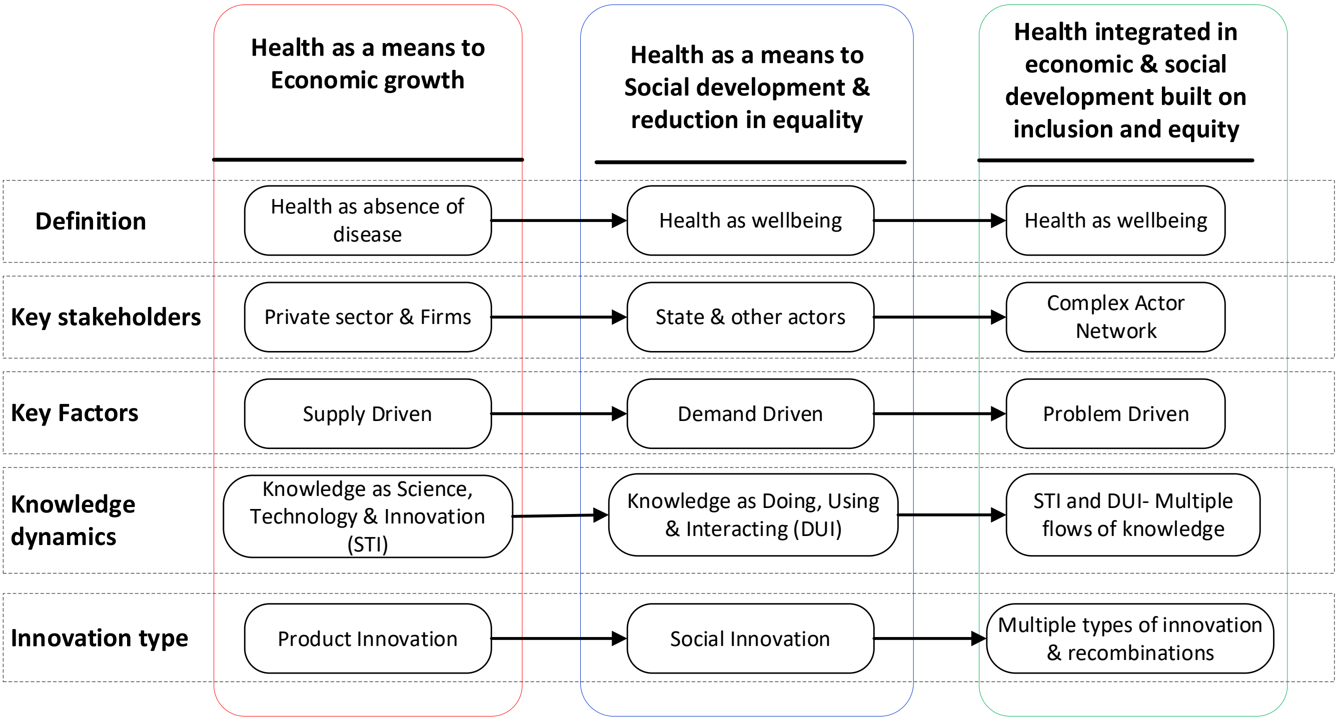

Figure 1.2: Health Policy Discussions and Development, edited from (Hanlin & Andersen, 2016)

Van der Merwe et al. (2020) also noted that a functional perspective is useful when it comes to understanding inclusive innovation in healthcare to guide mHealth projects. This is due to the exploration of the determinants of innovation and the systemic relationships which facilitate policy planning processes. This was exemplified through their Innovation for Inclusive Development Systems (I4IDS) framework. This study aligns with the processes in health systems strengthening with attention to the health information systems' design and accountability.

So in summary of stated barriers in this chapter, barriers to HIS development and strengthening in resource constrained environments include lack of funding, material resources (e.g. electricity outages, erratic internet connectivity and availability of IT infrastructure), inadequate human resources and inconsistent reporting requirements (Msiska & Nielsen, 2017), lack of data ownership and interpretation (Mukherjee, 2017) and lack of feedback where health workers rarely receive timely (positive) feedback (Moyo, Frøyen, Sæbo, *et al.*, 2015). Streamlining data collection and ensuring that data is standardised and collected through technological platforms are some of the ways that such inefficiencies are being addressed. Such platforms include electronic medical record and information gathering platforms such as OpenMRS, OpenEMR, GNU Health and District Health Information Systems (DHIS2).

1.4 Aim of the Research

The overall aim of this research to formulate a framework to manage (healthcare) innovation ecosystems built around platforms guided by innovation intermediaries and to trace their emergence. This comes from an acknowledgement that the interactions and activities between the actors and the innovation intermediary contribute to the value created in the ecosystem. Moreover, the overall goal is to identify key activities that can inform the innovation intermediary on how to make the ecosystem sustainable, especially in resource-constrained contexts.

1.5 Research Questions

Building on the preceding arguments in this dissertation relating to innovation ecosystems, intermediation and the value co-creation processes, the primary research question for this study is:

How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric healthcare innovation ecosystem?

By answering this question, the study aimed to contribute to the innovation ecosystems literature especially in developing countries. The composite table of the aspects that are answered in this dissertation are shown in Table 1.1. The sub-questions are all interlinked with each other and assist in the formulation of the framework of the dissertation; the related focus is in bold to show how it is all interlinked.

Table 1.1: Research Domain Development through Sub-research Questions

Main research question area of investigation	Research domain development	Sub research question
*How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric healthcare **innovation ecosystem**?*	Innovation Ecosystems	1. How are innovation ecosystems defined?
		2. What are the origins of this idea and how has it evolved over time?
		3. What are healthcare innovation ecosystems?
		4. How is it different from other systems perspectives of innovation?
*How do **innovation intermediaries** assist in the value co-creation process for firms in a platform-centric healthcare innovation ecosystem?*	Innovation Intermediaries	5. What is the definition of an innovation intermediary?
		6. What are the characteristics of an Innovation Intermediary?
		7. Which intermediary roles are important to the firms to promote value co-creation in the ecosystem
		8. How do they align with innovation ecosystem dynamics?
	Complex Adaptive Systems	9. What can the intermediary do in an innovation ecosystem?
*How do innovation intermediaries assist in the **value co-creation** process for firms in a platform-centric healthcare innovation ecosystem?*	Value Co-Creation	10. How do we define value co-creation in healthcare innovation ecosystems?
		11. What are the main dynamics and barriers to value co-creation in healthcare ecosystems?
How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric healthcare innovation ecosystem?	ALL	12. How do innovation ecosystems emerge and evolve around platforms?
		13. How do innovation intermediaries assist in the evolution, emergence and sustainability of the Innovation ecosystem?
*How do innovation intermediaries assist in the value co-creation process for firms in a **platform-centric healthcare** innovation ecosystem?*	Platforms in healthcare	14. What are the requirements for designing a framework to explain the emergence of the healthcare innovation ecosystem?

1.6 Research Gaps and Unique Contribution

There are various research gaps aligned with this study that outline its research contribution.

1.6.1 Theoretical Research Gaps

1.6.1.1 Ecosystem Structure Dynamics

Innovation ecosystems research has mainly focused on understanding the structure and dynamics of ecosystems (Moore, 1993; Oh, Phillips, Park, *et al.*, 2016; Shaw & Allen, 2018). Little attention has been given on the theoretical underpinnings and frameworks that address different relational dynamics that occur amongst ecosystem actors (Jacobides, Cennamo & Gawer, 2018; Ritala & Gustafsson, 2018). Such dynamics include aspects of value co-creation, network linkages and value appropriation in ecosystems which affect the effectiveness of the product or service the ecosystem is diffusing (Autio & Thomas, 2014; Schreieck, Wiesche & Krcmar, 2016; Thomas & Autio, 2012). Few studies have contributed beyond the descriptive nature of innovation ecosystems and their similarities to natural ecosystems (i.e. as a metaphor), with some studies being exploratory in nature (Shaw & Allen, 2018) or seeking to address conceptual inconsistency in identifying core elements across all types of ecosystems (Thomas & Autio, 2020). There are also a substantial number of literature reviews to explore and define the construct (Aarikka-Stenroos, Peltola, Rikkiev, *et al.*, 2016; Bogers, Sims & West, 2019; Gawer & Cusumano, 2014; Granstrand & Holgersson, 2019; Jacobides *et al.*, 2018; Oh *et al.*, 2016; Smorodinskaya *et al.*, 2017; Suominen, Seppänen & Dedehayir, 2019; Thomas, Autio & Gann, 2014).

The extant literature tends to identify the elements that make up ecosystems and outcomes achieved through ecosystem dynamics but fall short of governance issues, analysis of the relational connections and evolution between these elements (Oh *et al.*, 2016). A research direction proposed in literature is to test selected proposed theories, models and frameworks in relation to ecosystems and also look at the practicality of such proposed frameworks (Ritala & Gustafsson, 2018). One important study is by Thomas (2013) where he pointed out resource, technological, institutional and contextual activities on six digital service ecosystems that drive ecosystem emergence. This study aligns with Thomas (2013) and moves past structural dynamics; it seeks to trace the emergence and evolution of the innovation ecosystem through various focal functional activities.

1.6.1.2 Ecosystem Governance, Innovation Intermediation and Platforms

In a natural ecosystem, species compete, attack and consume each other but they are also mutually beneficial for each other (Shaw & Allen, 2018). This dynamic also happens in innovation ecosystems where actors can compete, collaborate or merge in order to create value, thus evolving the ecosystem. In an innovation ecosystem various actors have different business models, operational challenges and complementary needs (Shaw & Allen, 2018). Moreover, even the context of what value means to all the individual firms and actors in the ecosystem is varied (Adner, 2017; Adner & Kapoor, 2010). This strong interdependence comes to question how ecosystems are actually coordinated and managed for value creation and value appropriation (Autio & Thomas, 2014; Gomes, Facin, Salerno, *et al.*, 2018). This is where intermediation comes in.

Innovation intermediation is aligned with the facilitation of resources, configuration of conducive environments and brokering of services that promote the innovation process (De Silva, Howells & Meyer, 2018; Howells, 2006). Understanding the control mechanisms, internal attributes and workings of the value creation dynamics are of paramount importance to aid the governance strategies that help in creating and sustaining such ecosystems. These control mechanisms can be a shared platform, critical assets or pre-emptive alliances (Thomas *et al.*, 2014). Platforms are a source of various types of data that assist in ecosystem management and strategy as ecosystems use information as a source of streamlining activities (Shaw & Allen, 2018). Through proper knowledge and information management activities the complexity offered by platforms can be slightly alleviated through analysis of the information on the platform.

In this study there is an alignment of innovation ecosystems as having characteristics of complex adaptive systems (CAS) and making use of knowledge and information in the ecosystem. One main attribute of CAS is learning from historical events (Cilliers, 1998; Mitleton-Kelly, 2003). The storing of the actor interactions and historical events assists in understanding current dynamics or future alternatives for the ecosystem. However, in ecosystems, this information is not utilised properly due to lack of institutional arrangements that address data flows. This reinforces the call for a study into the roles, particularly, intermediation in ecosystems (Autio & Thomas, 2014). This study is aligned from this gap and explores how an intermediary can assist in the value creation process of firms in an innovation ecosystem. The study supposition is that by looking at the platform as a focal point, the ecosystem can be traced historically and hence it will be easier to assess the changing nature of the ecosystem that affects its effectiveness and productiveness.

1.6.1.3 Innovation Ecosystems in Emergent Industries

Most studies on ecosystem research have focussed on developed nations[2]. Context plays a key role in various dynamics that occur and affect ecosystem actors, how they create and maintain value as well as what is of importance to the ecosystem. The empirical work in this study focussed primarily on a developing country (often resource-constrained) context, though influence from a developed country context is evident in the use of typologies that are formulated from this research. Therefore, a contribution of this study is furthering the ecosystem literature pertaining to resource-constrained regions.

1.6.2 Health Systems and Sustainability Research Gaps

Further placement of the study is within the United Nations' Sustainable Development Goals, which are the agreed upon guidelines to achieve a better and more sustainable future for all. This study integrates well with the 3rd Sustainable Development Goal (SDG 3) to strengthen capacity of health systems, 9th Sustainable Development Goal (SDG 9) for sustainable

[2] A Scopus search on the term 'Innovation ecosystems' yielded 6,362 research documents. Over 1600 documents were from USA followed by the UK with over 700 documents. The rest of the research came from China, Australia and Europe (Italy, France, Spain, Canada).

innovation and 17th Sustainable Development Goal (SDG 17) that addresses operationalisation of technological capacity building through multi-stakeholder partnerships. These goals are further elaborated upon in Table 1.2.

Table 1.2: Sustainable Development Goals Study Alignment

SDG	ALIGNED WITH	RELEVANCE TO DISSERTATION
NUMBER 3 3 GOOD HEALTH AND WELL-BEING	Ensure healthy lives and promote wellbeing for all at all ages	• By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births • Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
NUMBER 9 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Build resilient infrastructure, promote sustainable industrialization and foster innovation	• Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all • Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020
NUMBER 17 17 PARTNERSHIPS FOR THE GOALS	Revitalise the global partnership for sustainable development	**Technology aspects:** • Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology • Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism **Capacity building:** • Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation **Multi-stakeholder partnerships:** • Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries • Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

This study aligns with the recurring call for capacity building and sustainable partnerships. Health systems in developing countries are plagued by several aspects and with more technological advancement the discrepancies have leaned towards capacity building, maintenance of platforms and utilisation of the data gathered for strategic planning purposes (World Health Organization, 2007). The empirical focus informs how an intermediary such as the health ministry can be better equipped to manage platforms that require a particular level of expertise that the ministry does not have. An example is the utilisation Free and Open Source Software (FOSS) that is developed elsewhere as the fundamental platforms of the healthcare innovation ecosystem. Moreover, when it comes to healthcare applications, such as those used in mHealth, an ecological perspective has been proposed to assist in understanding the reciprocity between different components and the fit of a mHealth implementation more holistically (Braa & Nielsen, 2013).

1.6.3 Summary Study Placement

The main streams that encompass this study are innovation ecosystems, innovation intermediation, innovation systems and complex adaptive systems. The objectives are to 1) map out the emergence of the ecosystem around the platform; 2) identify what value means to the actors; and 3) how it is created and appropriated in the ecosystem. Figure 1.3 is a depiction of the different ecosystem literature streams that are aligned with this study and the various research gaps that this study aimed to address.

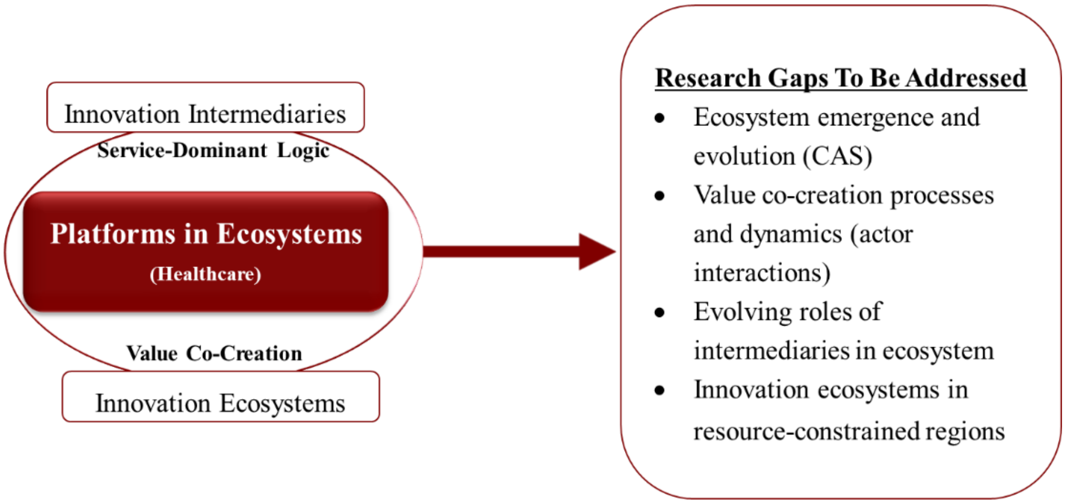

Figure 1.3: Study Placement and Research Gaps

1.6.4 Research Outputs and Relation to the Study

The current peer-reviewed research outputs from the research were reflective of the progress that the study undertook. Initially, perspectives of open innovation and the innovation intermediation which aligned with entrepreneurial ecosystems were outlined which stemmed from a study that the author had previously completed. This progressed to understanding and applying key innovation concepts as reflected upon by Schumpeter (1934) of innovation being new (re)combinations of ideas, and Drucker (2014) identifying intrinsic and extrinsic innovation sources to ecosystems. This later evolved to answering the key questions of *how does one identify and manage innovation* in an ecosystems perspective. That's where most of the publications lie in outlining tools and research methods that can assist in the investigation of such dynamics. This included looking at the complexity of innovation ecosystems, investigation of research methods that help in understanding them and the conceptualisation of identifying leverage points and attractors from a complexity science angle. A summary of the research outputs is shown in Table 1.3 below.

Table 1.3: Research outputs from the study

Domain	Study Question	Research Output
Innovation Ecosystems Construct	• How do we define innovation ecosystems? What are the origins of this idea and how has it evolved over time? How is it different from other systems perspectives of innovation? • How do ecosystems emerge and evolve around platforms? • Relation to Complex Adaptive Systems	*1.* Journal paper under review titled (2020): *Towards Understanding Evolutionary Innovation Intermediation for Inclusive Healthcare Innovation Ecosystems Management* *2.* Journal paper under review titled (2020): *Making sense of the unknown: Using Change Attractors to explain Innovation Ecosystem Emergence* *3.* IEEE International Conference on Technology Management, Operations and Decisions (2020): *Event Structure Analysis as a Tool for Investigating Sustainability in Innovation Ecosystems* *4.* Druid Conference paper (2019): *Learning from the Past: Soft Systems Methodology as a Tool for Reflective Innovation Ecosystem Management*
Innovation Intermediaries and Value Co-creation and Intermediary Dynamics in the Ecosystems	• What are the characteristics of innovation intermediaries? • How do we define value co-creation in healthcare innovation ecosystems? • What are the main dynamics and barriers to value co-creation in healthcare ecosystems? • What interaction processes aide in value co-creation amongst actors, the platform and the intermediary in the ecosystem? • Which intermediary roles are important to the firms to promote value co-creation in the ecosystem?	5. ISPIM conference paper on example framework titled (2018): *Towards understanding Platform Intermediaries in Innovation Ecosystems using Schumpeterian Ideas* 6. IEEE Conference paper titled (2018): *Platforms in the Healthcare Innovation Ecosystems: The Lens of an Innovation Intermediary* 7. Journal article titled (2017): *The role of open innovation intermediaries in entrepreneurial ecosystems design*

1.7 Chapter Conclusion

This chapter has provided the context and overview of the dissertation. It has addressed the research gaps, reasoning and research outputs. The next chapter gives an outline of the research design and methodology utilised in this study, giving an outline of how the study was conducted and the various methods that were utilised to answer the research questions.

Chapter 2: Research Design and Methodology

"The heart and soul of good writing is research; you should write not what you know but what you can find out about." —Robert J. Sawyer

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This chapter introduces the the research methodology and design that was utilised to answer the study research questions. This is the 2nd stage of the Soft Systems Methodology (SSM) shown in Figure 2.1. This chapter also aims to clarify how the SSM is undertaken and what the significance of the methodology is in the study.

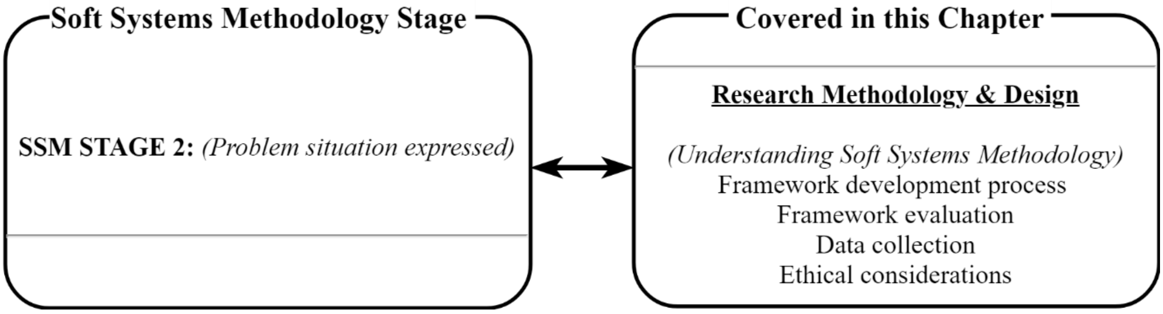

Figure 2.1: The Structure of Chapter 2 within the Context of the Soft Systems Methodology

2.1 Research Approach

The primary purpose of this study was to develop a framework that can be used as an aid to assist in the governance of the value co-creation dynamics achieved through an intermediary in a platform-centric healthcare innovation ecosystem. In order to assess and analyse healthcare innovation ecosystems, there are various approaches that may be applicable.

The study was based on an ontological research philosophy. Ontology is "*an explicit specification of a conceptualisation*" (Gruber, 1993: 199) where the specification entails representational definitions and vocabulary aligned with what is under investigation. This adheres to the need to have proper definitions around innovation ecosystems and the creation of value. This was investigated through qualitative case studies from an interpretive paradigm with the aim to explore, interpret and describe the value creation dynamics that are occurring around the healthcare innovation ecosystem and develop better insight whilst testing or generating theory (Eisenhardt, 1989; Wilson, 2014; Yin, 2009).

Of importance in this study was the consideration of how the study is undertaken and analysed and considering that an innovation ecosystem is a complex system, this was of great significance. This led to the selection of the Soft Systems Methodology, that will be explained in the following section. Reductionism plays a key role when it comes to using Soft Systems Methodology (SSM) to assess innovation ecosystems. Reductionism in complex systems is aligned with the reductionist approach from Descartes where the complex system is reduced to fundamental basics or the interactions of the different parts of the system (Descartes, 2000). Reductionism is " *the attempt to explain a complex interrelated whole in terms of its simpler elements or parts or in terms of elements belonging to a lower level of phenomena*" (Sloane, 1945: 217). It can be undertaken in various ways primarily through *ontological reductionism* (the whole of reality consists of a minimal number of parts/entities), *methodological reductionism* (explains the system scientifically in terms of the smaller entities) and *theory reductionism* (new theories do not replace or absorb older one but are reduced to basic terms with respect to derivation, translation and explanation). It is noted that using reductionism by itself would hinder a comprehensive outlook of the study as it would aid in building a description of the ecosystem from its subsystems whilst ignoring the relationships between the actors and subsystems (Sloane, 1945). This is one of the main reasons why the study adopts the concept of emergence (i.e. the existence and formation of collective actor behaviours in the system –what parts of a system do together that they would not do alone) but still utilises aspects of reductionism as the concept of a system is itself a limited form of reductionism (Sloane, 1945).

In this study, the reductionist perspective is utilised in the identification of the aspect of the system that is being assessed whilst emergence is aligned with the relationship between the actors. So, in applying soft systems thinking to innovation ecosystems there is rudimentary hierarchical analysis where the researcher starts from the role of the observer asking, '*what am I observing*?' and paints the whole picture. Hierarchy is a source of insight and in this study is expressed through the narrative and systematised literature reviews.

2.2 Research Methodology

2.2.1 Understanding Soft Systems Methodology

Checkland formulated the Soft Systems Methodology (SSM) as a method for understanding business management problems through human activity systems (Checkland, 1981). It was primarily used in action research to offer an organised way of thinking specifically in systems that have different actors with divergent views of the problem such as the management of information systems (Wilson, 2001). This is usually around "soft" problems which are problems that are ill-defined, intangible and not easily quantifiable. The method digressed from traditional 'hard' systems-based mechanistic thinking to integrate human oriented social systems often referred to as 'soft' systems. The process of undertaking SSM starts with ill-defined unstructured problem situations that require rigorous understanding particularly in complex environments (Checkland, 1981; Durant-Law, 2005; Rose, 1997; Wilson, 2001). SSM centres around four core activities, namely (Checkland, 2000):

1. *Problem Identification*: what is the problem including political and cultural issues;
2. *Model building*: formulation of conceptual and activity models;
3. *Situation analysis*: understanding and debating the situation using the models on:
    a. changes that would improve the situation and are regarded as both desirable and (culturally) feasible, and
    b. the commitments between conflicting interests, which enable action to improve to be taken;
4. *Taking action*: steps taken in order to foster the situation's improvement.

These activities are outlined in 7 distinct cyclical steps that link the real world with the systems-world that were outlined by Checkland (1981). These are categorised as the 'real-world' (stages

1,2,5,6 and 7) and 'systems thinking or abstract world' (stages 3 and 4). The problem situation is expressed from being unstructured to an understandable structured way; root definitions of the different aspects in the system are developed by the analyst/researcher; conceptual models of what might work in the system are put forward and a process of comparison of the conceptual models with the real world is undertaken. The desirable changes are applied to the conceptual models and implemented through action. Any improvements go through the same cyclical process. (Checkland, 1981; Checkland & Haynes, 1994; Rose, 1997; Wilson, 2001). The stages are described in Table 2.1.

Table 2.1: Description of Soft System Methodology edited by author from (Checkland, 1981, 2000)

Application Area	SSM Stage	Description	Objective
Real World	1. Problem situation unstructured 2. Problem situation expressed	The problems situation is identified and represented in terms of a rich picture	Define the problem at a high level, preferably without imposing a particular structure
Systems World	3. Root definitions of relevant systems	A root definition of a relevant system is developed for a particular point of view. The root definition describes what the system is and what it is to achieve	Capture a particular view of a system which might address the problem situation. The system is defined in the context of the organisation and the viewpoints of affected individuals.
	4. Conceptual Models	A model showing the interconnected activities is developed. The model is developed from the description of the system defined in the root definition	Develop a formal model of the system including transformative activities and their interactions. Defines necessary flow of information and decisions that comprise the system
Real World	5. Comparison of conceptual models with the real world	The conceptual model is compared to the real-world situation	Identify needed changes
	6. Feasible, desirable changes	Possible changes to the system are identified through the differences in the conceptual model and the real-world situation	Define actions to induce feasible and desirable changes to the real-world situation
	7. Action to improve	Chosen actions are implemented	Creation of a new expectedly more desirable actions

The reasoning strategy of SSM centres on modelling abstract features of what the problem is and forming textual definitions aligned with the problem. This forms root definitions as well as devices that are utilised to improve the problem solver's interpretation of the problem-cyclical process shown in Figure 2.2.

The flexibility of the activities in SSM cements the relevance of the methodology in tracing the emergence of innovation ecosystems or analysing what can be salvaged from failed innovation projects. SSM is one of the most distinctive approaches in the area of applied systems thinking, bringing clarity to multi-stakeholder situations (Bernardo, Gaspar, Henggeler Antunes, *et al.*, 2018; Checkland, 2000).

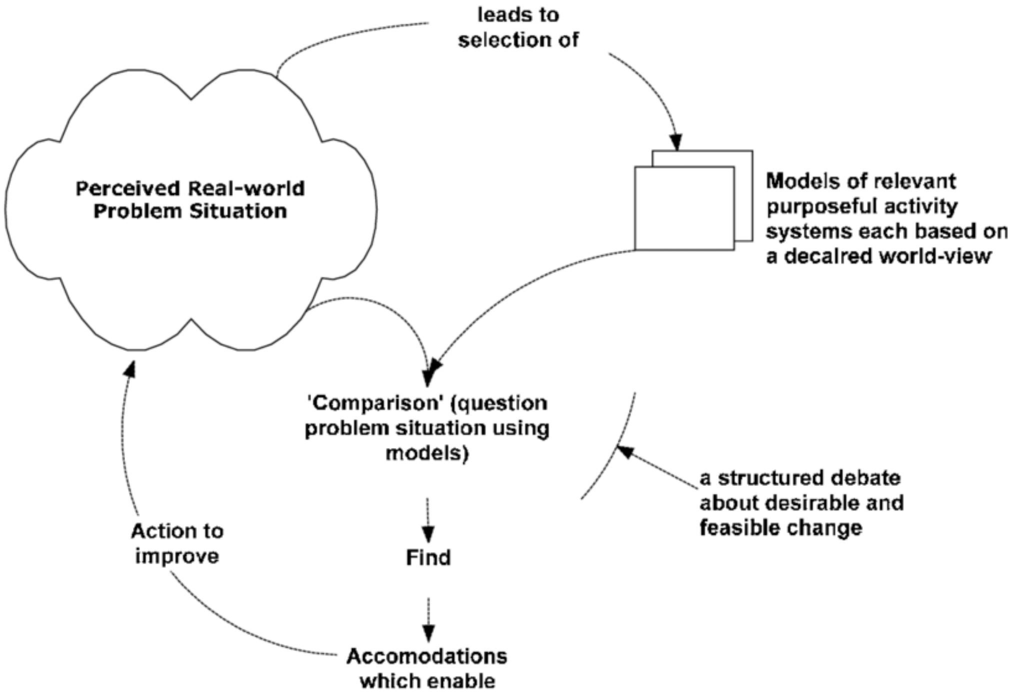

Figure 2.2: The Inquiring/Learning Cycle of SSM (Checkland and Scholes, 1990)

SSM supports model building through conceptualisation, layered thinking and visualisation. Comparison between conceptual models with the real-world offers shared insights about *what should be* and, in an iterative manner, allows purposeful action to be taken.

Rose (1997) outlined how SSM can be utilised in social science as:

1. a *problem-structuring* tool – where SSM gives the structure to the research problem which can be answered by other methods
2. a *good-fit* research tool – aligned with qualitative, activity based interpretive and systems-based research areas and objectives
3. a *triangulation* tool – where SSM is the method that confirms, refutes or amplifies findings obtained by another method
4. a *theory-testing or generation* tool – the learning processes in SSM can be expressed as theory
5. a *coordinative* or *directive* tool – where SSM provides a common basis for transdisciplinary research and delineation of various activities and logical dependencies in the research process

Though this study is in the engineering discipline, these categorisations above still apply and, in this study, SSM was used as a directive and problem structuring tool.

2.2.1.1 Appropriateness of SSM to the study

It is important to have tools that guide the formulation of the framework with which to map the ecosystem value creation process flows. As this study considered the role of innovation intermediaries in innovation ecosystems, and as case studies were undertaken, SSM was utilised as a problem structuring and directive tool that is a referral point for how the study analyses and organises the literature. The problem structuring aspects are done in three primary ways: innovation intermediary role definition, ecosystem mapping and healthcare innovation ecosystems definition. Firstly, in understanding the roles of innovation intermediaries in innovation ecosystems from a theoretical perspective; secondly by mapping out the problem structure, dynamics and ecosystem around the study cases (MAMA, MomConnect and DHIS2) and thirdly, utilising SSM as a basis for giving definitions that are utilised in understanding and explaining healthcare innovation ecosystems and hence formulation of the framework through literature and integration of innovation theories. The directive aspects are expanded on in Section 2.4.1 of analysis.

Checkland (1981, 2000) put forward that success of SSM was based on information sharing in an iterative fashion to ascertain the dynamics in the system. This has resulted in an increase in the usage of SSM as a methodology in engineering, business and social sciences (Mingers, 2000; Warren, Sauser & Nowicki, 2019). The attractiveness of utilising SSM for the study is due to the fact that innovation ecosystems that have no formalised tools for analysis (Oh *et al.*, 2016; Ritala & Gustafsson, 2018) and, hence this study puts SSM forward as a suitable approach. SSM has a number of concepts such as a CATWOE analysis that can be used both for ecosystem description and analysis. CATWOE stands for Customers, Actors, Transformation, *Weltanschauung* (world view), Owner and Environmental constraints (CATWOE) (Brown, 1992; Checkland, 1981; Wilson, 2001). A CATWOE analysis requires the inputs to be listed and an outline of the transformative nature of change these inputs undergo to become the system outputs.

More specifically, CATWOE is outlined as:

- *Customers*: users /stakeholders who benefit or suffer when the system changes.
- *Actors*: are those responsible for implementing system changes.
- *Transformation*: the conversion process from a system input to an output.
- *Weltanschauung*: also known as “Worldview". It is the justification for the transformation of the system or process and entails placing the process or system under analysis in its wider context to highlight the consequences or relevance of such process to the overall system.
- *Owner*: the actor(s) that has the authority to make system changes such as to stop the project
- *Environmental constraints*: are external system constraints.

Of note is that when applying CATWOE on an innovation ecosystems perspective, the customers, platform owner and actors may all be defined as ecosystem actors. For the systems perspective of this study, Soft Systems Methodology (SSM) is utilised as a referral point of how the overall study is undertaken. The integration of the SSM stages, framework development process and sections of the dissertation are shown in Table 2.2. This is linked to Jabareen's (2009) framework development process which will be explained later in the chapter. So, fundamentally the requirements of the framework are to ensure that model building, and situation analysis are aspects that are thoroughly covered.

Table 2.2: Mapping SSM, Chapter Numbers and Framework Analysis Phases

SSM Stage	**Dissertation Chapter**	**Framework Phase** (Jabareen, 2009)
1. Problem situation unstructured	1. *Introduction*: (Rationale Scope, Dynamics of Health systems strengthening, Research question, Research Gaps)	**1.** Mapping the selected data sources
2. Problem situation expressed	*2. Research design*	
3. Define relevant purposeful activity system root definitions	3. *Innovation Ecosystems* *(Technology) Innovation Systems* *The role of Knowledge and Learning in Innovation (Ecosystems)* *4. Complex Adaptive Systems* 5. *Innovation Intermediation* 6. *Value Co-Creation in Innovation ecosystems*	**2.** Extensive reading and categorising of the selected data **3.** Identifying and naming concepts **4.** Deconstructing and categorising the concepts
4. Develop conceptual models of purposeful activity systems	*7. Conceptual Framework Development*	**5.** Integrating concepts **6.** Synthesis, re-synthesis, and making it all make sense
5. Compare conceptual models with the real world	*8. Evaluation*	**7.** Validating the conceptual framework
6. Ensure changes are systematically desirable and culturally feasible	9. *Validation*	**8.** Rethinking the conceptual framework
7. Define action to improve the problem situation	10. *Final Proposed Framework* *11. Conclusions and Future work*	

2.2.1.2 Limitations of SSM

There are some discrepancies in the SSM domain. Scholars like Salner (1999) offered a critique of SSM and outlined the difficulties that novice researchers encounter when utilising the methodology. These entail lack of clear validity, value measurement and a lack of depth when analysing the political and social contexts in which SSM is being applied. SSM primarily focuses on human activity systems and looks at the characteristics and dynamics of such systems. However, in any system there are aspects which cannot be measured quantitatively and are intangible. To address such disparities, SSM offers flexibility to integrate with other methodologies, such as Grounded Theory (GT), that offers complementary aspects to the shortcomings of SSM (Brown, 1992; Durant-Law, 2005). This complementarity is very useful as GT will be utilised in the case studies and is shown in Table 2.3.

Table 2.3: Comparison of GT and SSM Source: (Durant-Law, 2005)

Steps	Soft Systems Methodology (SSM)	Grounded Theory (GT)
1	The problem situation unstructured	An unexplained phenomena or process
2	The problem situation expressed	The phenomena or process identified for study
3	Root definitions of relevant systems	Data collection and coding
4	Conceptual model construction	Theme extraction
5	Model and problem situation comparison	Postulate generalisations
6	Feasible and desirable change construction	Develop taxonomies
7	Action to improve the situation	Theory development

Furthermore, SSM is purported to offer a participative consensus as the input from diverse system actors is supposed to be included in the system analysis (Checkland, 2000). In the context of this study, which is healthcare innovation, projects and interventions are constrained around factors such as political and economic conditions, expertise and funding amongst other things. Fragmentation usually happens when a new funder proposes implementation of a new technology or service that requires a new learning curve, stalling progress towards meeting national, regional or global (SDGs) strategies. The emergence of new projects and dissolution of old projects results in the loss of knowledge and strategic groundwork such as feasibility studies and user education which means that a lot of tangible and intangible value is lost in the implementation of every new project. Using SSM as a tool to assess ecosystem emergence as well as understand purportedly 'failed' or past intervention projects to see what can be salvaged or re-used is one way of speeding up the innovation ecosystem growth process. SSM offers an opportunity to document, optimise or leverage change in a system.

2.2.2 Event Structure Analysis and Case Study Conceptualisation

Although SSM has been noted as a good starting point for mapping a CAS, it has also been acknowledged that no single tool can be expected to provide complete and holistic guidance (Ramalingam, Jones, Reba, *et al.*, 2008). As mentioned in the previous section, Grounded Theory was utilised in the study as a way of achieving depth of analysis and insight from the case analyses. However, a structure for investigating ecosystem dynamics and to construct the narratives was important to consider in the study, so it was deemed necessary to identify another method of analysis.

2.2.2.1 Construction of the Narrative

In this study the construction of case study narratives and ecosystem mapping was done in a systematic way using Event Structure Analysis (ESA). ESA is a technique that allows researchers to study the social processes that lead to the occurrence of an event. The technique is described as a process approach that identifies abrupt changes from longitudinal data in a system and classifies them as events, offering the possibility of operationalising and measuring system functions in relation to events (Griffin & Griffin, 2010; Griffin, 1993; Heise, 1989). It is also closely aligned with qualitative methods such as Sequence analysis (Abbott, 1995) or Process analysis (Hekkert, Suurs, Negro, *et al.*, 2007a).

ESA is deemed a valid approach for undertaking, analysing and presenting in-depth descriptions of the cases in a study through the logical sequence and the social aspects that unfold around such activities (Abbott, 1995; Heise, 1989; Macindoe & Abbott, 2004). It is used to analyse history as a "*sequence of events, and apply it to the analysis of a case study of planned social change*" (Stevenson, Zinzow & Sridharan, 2003: 43). It assists with the unpacking and re-composition of events to construct the causal interpretation of what happened and why (Ponti, 2012).This is done through two independent analyses.

The first is a *compositional analysis*, that helps describe how events in a narrative associate people, things and actions; where the narrative is constructed through a storyline consisting of sequences of events (Van de Ven, Angle & Poole, 2000). The second is a *linking analysis* which helps identify the types of linkages between events (Heise, 1989). An event incorporates the decisions and actions of actors, or action in the greater environment. The narrative is the organised developmental sequence of events in which the content is structured into a single coherent story, which may or may not have subplots (Abbott, 1995; Poole, Dooley, Holmes, *et al.*, 2000). ESA's narrative includes temporal order, connectedness and events; it helps with inferring causal links between the actions amongst actors and identifies their contingencies and consequences (Griffin & Griffin, 2010). This is key to the nature of cases analysed in this study and aligns with Abbott (1983) who contends that "*If one wishes to generalize in terms of stories, one must carefully examine the basic constituents and characteristics of social sequences*."

This is a method of analysis that has been proposed as a comprehensive way of explaining continuous change as a factor of causation as well as includes the order of events especially in systems of innovation (Hekkert *et al.*, 2007a) and to analyse comprehensive community initiatives (Stevenson *et al.*, 2003). More interestingly, ESA has the potential to be modelled on software platforms. An example is the software modelling tool called ETHNO[3] that was developed to transform the raw or chronological narrative data entered by the analyst into causal relations that formulates the narrative (Griffin, 1993; Heise, 1989). It has been utilised in medical studies (Uehara, 2001), organisational studies (Ponti, 2012), and social studies (Stevenson *et al.*, 2003). Although very promising initially, ETHNO was not used in this study as the software has been discontinued.

Therefore, SSM was utilised to give an overall methodological approach for the study. On the other hand, Event Structure Analysis (ESA) was used to give an overview of what is happening conceptually throughout the whole ecosystem; it was used to map actors and develop a narrative to explore and understand the dynamics around knowledge flows in the ecosystem. The foundational assumption is that such combinations give a holistic explanation to the dynamics that have occurred and are occurring in the innovation ecosystem.

[3] http://users.ox.ac.uk/~ctitext2/resguide/resources/e150.html

ESA is very closely linked to Event History Analysis (EHA) also referred to as Event History Analysis (EHA) (Negro & Hekkert, 2008), or Survival analysis[4]. Whilst ESA is a qualitative methodology, EHA is more of a quantitative or mixed methods methodology where events are counted for frequency of occurrence (Hekkert, 2008; Suurs, 2009). Event history analysis consists of a well-developed set of statistical techniques (both exploratory and multivariate) that study events, when they happen, and which factors influence the occurrence of various types of events. This methodology is well suited for the testing or evaluation of data where the dependent variable is discrete and typically dichotomous (Castilla, 2007). This methodology has been utilised in epidemiology studies when tracking outbreaks or biostatistics done using statistical methods that focus on questions related to timing and duration until the occurrence of an event (Allison, 1984; Mills, 2011). On the systems level, EHA was used to chronologically map, interpret and align with different episodes, periods of time and processes occurring in the system to identify or explain system dynamics (Negro & Hekkert, 2008; Suurs, 2009). These events are then stored in a database and iteratively classified into categories where each of the categories are allocated to the system functions. Once they are categorised, narratives need to be undertaken as the narratives give meaning and a voice of reflective agency to a system (Uprichard & Byrne, 2006).

2.2.2.2 Mapping of Leverage Points and Attractors

This study goes a bit further from just identifying the ecosystem events, it examines the main categorisation and impact of these events (termed leverage points). The concept of leverage points and attractors will be further explained in Chapter 4. Since an ecosystem evolves, being able to understand it at a single point in time will not provide enough information on the proponents or hindrances to the innovation process in the ecosystem. ESA offers an opportunity to offer holistic and analytical narratives of the ecosystem dynamics and is a relevant method for this study. Moreover, what makes it ideal is that knowledge is the central aspect of analysis. The main onus is to answer the question of how to show associations amongst narratives. Hence, ESA is the more applicable methodology.

In the cases explored in this study ESA was used to understand the dynamics around knowledge flows in the ecosystem, whilst SSM was utilised to give an overview of what is happening conceptually throughout the whole ecosystem and to map actors. Of importance is how these attractors lead to the ecosystem emerging or evolving in a particular way as the occurrence, in itself, of an event is not a true indicator of the impact that the ecosystem function has on the sustainability of the ecosystem. Mapping of the events in ESA is done from the collection of data from various data sources such as archival data (newspapers, magazines, and reports), scientific publications, patent databases, ecosystems actor forums and the data can be subjectively based on the interpretation by the researcher (Stevenson *et al.*, 2003). The way that ESA integrates with SSM is shown in Figure 2.3 .

[4] *Event history analysis* is primarily used in sociology and closely allied disciplines. Elsewhere the methodology is known as survival analysis (biology and medicine), failure-time analysis (engineering), or duration analysis (economics). Ref: https://www.encyclopedia.com/social-sciences/encyclopedias-almanacs-transcripts-and-maps/event-history-analysis.

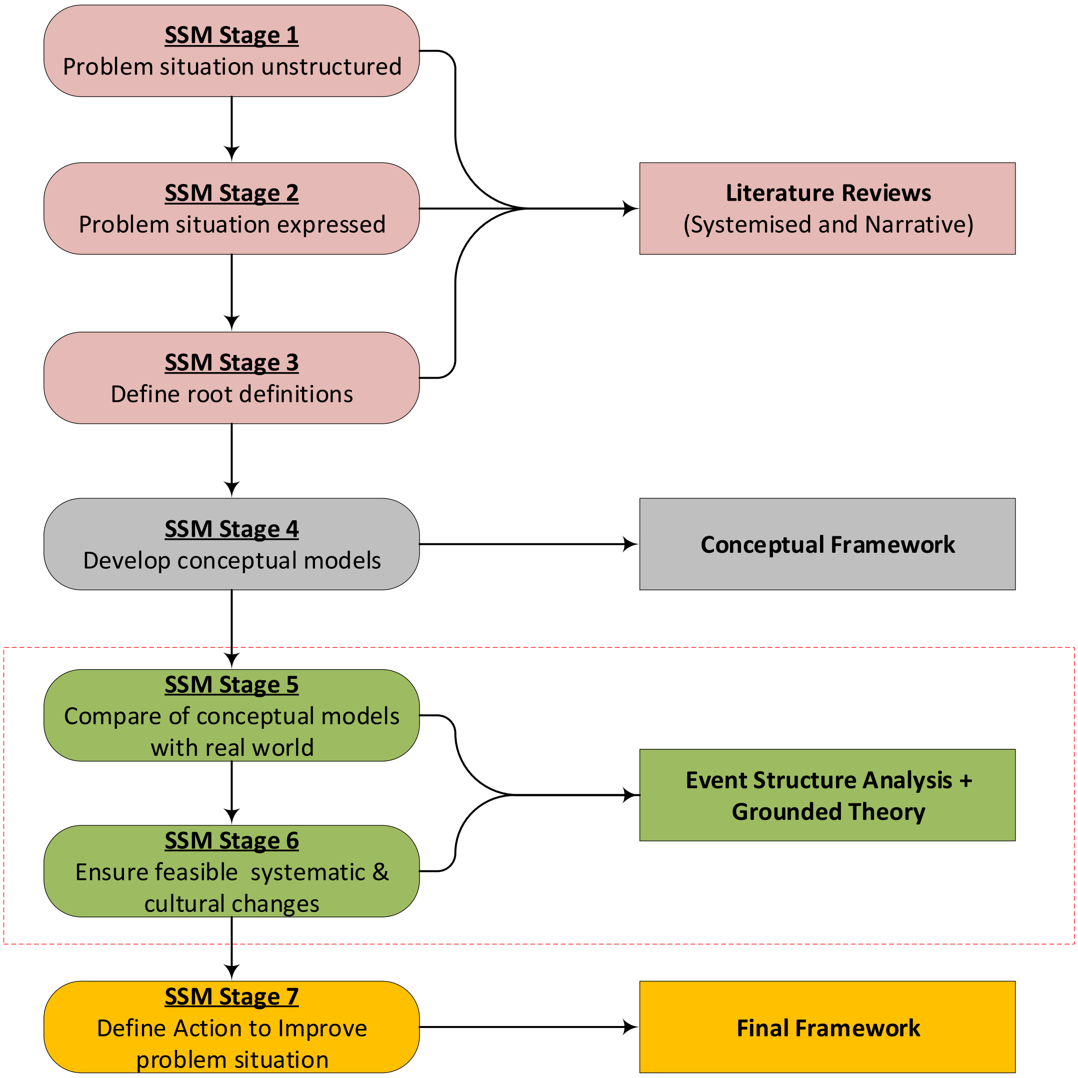

Figure 2.3: SSM Stages and Selected Methods Used in the Study

The following section describes how the framework was developed and the guiding principles for that particular section which relate to Stages 4 to 7 of the Soft Systems Methodology.

2.3 Framework Development Process

Most social phenomena are complex and linked to a multiplicity of bodies of knowledge, hence a multidisciplinary approach is required to be able to fully understand such different concepts from a research perspective. Authors have offered various qualitative and systematic ways for building conceptual frameworks (Jabareen, 2009; Maxwell, 2013). Miles, Huberman and Saldana (2014) defined a conceptual framework as a visual or written product, one that "explains, either graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables—and the presumed relationships among them" (p. 18) cited in (Maxwell, 2013). Jabareen (2009) defines a conceptual framework as "*a network, or 'a plane,' of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena. The concepts that constitute a conceptual framework support one another, articulate their respective phenomena, and establish a framework-specific philosophy*"

(Jabareen, 2009: 51). These two definitions outline how the framework is an informed guide for the dissertation and helps when it comes to focus.

Concepts are usually taken from literature and involve a range of processes where every concept has components that define it from a GT perspective (Jabareen, 2009; Rocco & Plakhotnik, 2009). A conceptual framework offers an understanding and an interpretative approach to social reality and can be developed and constructed through a process of qualitative inquiry (Jabareen, 2009; Maxwell, 2013). The framework aims to relate relevant theories, concepts and empirical research to advance and systematise knowledge on the research topic (Rocco & Plakhotnik, 2009). It is of primary importance that the framework is an outline of the tentative theory of the phenomena that is under investigation in the study and is a continuous interplay between data collection and analysis (Maxwell, 2013). Jabareen suggested 8 phases that align with how the conceptual framework is formulated as shown in Table 2.4. This study took the phases as a guide for informing **Stage 4** (*conceptual model development*), **Stage 5** (*comparison with reality*), **Stage 6** (*ensure changes*) and **Stage 7** (*actions to improve*) of SSM.

Table 2.4: Conceptual Framework Phases from (Jabareen, 2009)

Phase of Conceptual Framework	Description	Action in Study
Phase 1	*Mapping the selected data sources*	• map the spectrum of multidisciplinary literature regarding the phenomenon in question • extensive review of the multidisciplinary texts
Phase 2	*Extensive reading and categorising of the selected data*	• read the selected data and categorise it
Phase 3	*Identifying and naming concepts*	• read and reread the selected data and "discover" concepts-primarily using GT methodology
Phase 4	*Deconstructing and categorising the concepts*	• deconstruct each concept; to identify its main attributes, characteristics, assumptions, and role
Phase 5	*Integrating concepts*	• integrate and group together concepts that have similarities to one new concept
Phase 6	*Synthesis, resynthesise, and making it all make sense*	• synthesise concepts into a theoretical framework
Phase 7	*Validating the conceptual framework*	• whether the proposed framework and its concepts make sense not only to the researcher but also to other scholars and practitioners
Phase 8	*Rethinking the conceptual framework*	• revision of the theoretical framework according to new insights, comments, literature

In line with these assertions the conceptual framework was an integrative process aligned with considering the innovation ecosystem, attributes of the innovation intermediary and how the actors interact and exchange different types of knowledge flows in the ecosystem. The initial framework was presented to experts at a five-month doctoral fellowship that the author took part in from February to June 2019 at Aalborg University under the Innovation Knowledge and Economic Dynamics research group in Denmark[5]. Feedback was given on the soundness of

[5] https://www.africalics.org/wp-content/uploads/2019/05/AfricaLics_Newsletter-2018-2019.pdf

linking the aspects of innovation systems and the knowledge integration process considerations.

2.3.1 Framework Verification, Data collection and Evaluation

Multiple case replication was undertaken using various sources (Creswell, 2013; Yin, 2009). Data was triangulated through i) theoretical perspectives of intermediation, CAS and ecosystems; ii) feedback from 4 seminars on a 5 month fellowship; iii) document analysis and archival records; iv) interviews; v) multiple case replication of 3 cases using event structure analysis all guided by SSM.

The cases were of the MAMA, MomConnect and DHIS2 communities. Each case study yielded insights for each particular innovation ecosystem and it is necessary to combine results from multiple cases in order to strengthen the results through a logic of replication (Yin, 2009). Combining data collection methods enables researchers to draw upon multiple sources of evidence and seek convergence from different data sources in order to improve the credibility and validity of the study whilst decreasing the researcher's bias (Yin, 2009).

An interpretive GT approach was used to understand the cases and link back to literature due to the exploratory nature of the study. It is an inductive methodology that attempts to bridge the gap that is between research and theory in research areas where there is little understanding of the social processes at work (Glaser & Strauss, 1967; Hunter, Murphy, Grealish, *et al.*, 2011). More importantly, this study aimed to use iteration whilst undertaking the analysis through a reflexive process. This is important in order to develop meaning and spark insight (Srivastava & Hopwood, 2009). Reflection was undertaken with the aim of testing:

1. Applicability of the framework
2. Insights from every stage of the evaluation and data analysis
3. Identification of specific labelling and categorisation of leverage points from the case studies

The process that was followed is shown in Figure 2.4.

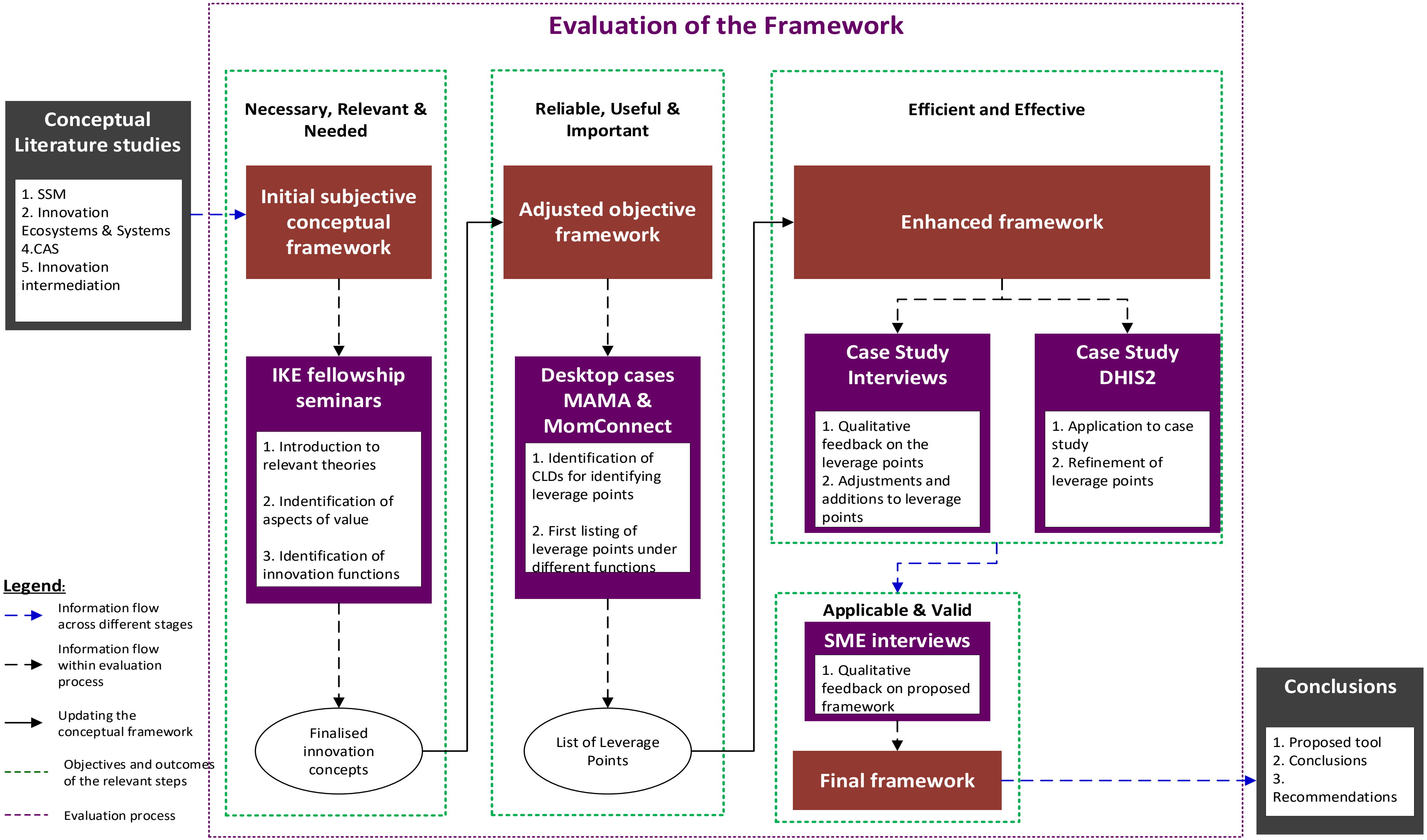

Figure 2.4: Conceptual Framework Evaluation Process

GT has 3 prominent approaches, namely classical grounded theory (Glaser & Strauss, 1967), interpretive grounded theory (Corbin & Strauss, 2015) and constructivist grounded theory (Charmaz, 2014). The classical GT approach is based on the concept that theory should be derived from data that has been systematically analysed in social research (Glaser & Strauss, 1967). This is derived from more of a positivist perspective where knowledge is based on experiences of the senses and obtained from experimentation and observation (Sebastian, 2019). However, Strauss and Corbin asserted that theorising from data only is a bit obscure and hence introduced an interpretive paradigm. There are elements in the process such as human agency, emergent processes, social and subjective meanings that make grounded theory an iterative process (Corbin & Strauss, 2015). Charmaz (2014) who was a student of both Glaser and Strauss, introduced Constructivist Grounded theory. She acknowledged that there was a clear interaction between the researcher and subject of the research. However, some researchers have noted that constructivist grounded theory is more of a mix of both the classical and interpretive streams of grounded theory (Hunter *et al.*, 2011; Sebastian, 2019). Overall, researchers that use GT do so with the intent to provide a practical theoretical explanation for a complex problem (Sebastian, 2019). Some distinctions between the three types of GT are outlined in Table 2.5.

Table 2.5: Comparison of the three types of grounded theory edited from (Hunter *et al.*, 2011; Sebastian, 2019)

	Classic	Straussian	Constructivist
Philosophical influence	• (attempts to be) free from influence	• Interpretivism	• Constructivism and pragmatism
Identifying the problem area	• Emergent. • No initial literature review	• Experience related • Literature dependent	• Sensitising concepts • Discipline-specific
Role of the researcher	• The researcher is distant and detached	• The researcher is engaged with and actively interprets the data	• The researcher constructs rather than discover
Conduct of research and developing theory	• Laissez-faire theory generation.	• Paradigm model theory verification	• Co-construction and reconstruction of data into theory.
Relationship to participants	• Independent.	• Active	• Co-construction
Evaluating theory	• Fit, work, relevance and modifiability	• Validity, reliability, efficiency and sensitivity	• Situating theory in time place, culture and context. • Reflexive rendering of the researcher's position.
Coding	• Open coding • Selective coding • Theoretical coding	• Open coding • Axial coding • Selective coding	• Line-by-line conceptual coding and focused coding to synthesise large amounts of data

For this study the Straussian approach was used as literature reviews were undertaken and reference was made to conceptual descriptions of the innovation ecosystem construct (Halaweh, Fidler & McRobb, 2008). Hence, GT was mainly used for the intermediary roles and activities in literature review and data analysis in order to extract, identify and develop themes arising from the literature that can be traced back to value co-creation and appropriation within a healthcare innovation ecosystem. Furthermore as the study looked at the emergence of an ecosystem around a platform, a GT approach was suitable as it is important that the study must not impose any pre-conceived ideas about the ecosystem construction by design (Eisenhardt, 1989). Through the assessment of the platform and its interactions this can give rise to emergent theoretical categories and not about the phenomenon under investigation. In order to identify the dynamics and map activities that attribute to leverage points in the case studies, a longitudinal view of the innovation ecosystem is important.

The case selection was based on the following main aspects (Creswell, 2013; Yin, 2009):

- accessibility of data and interview candidates
- generalisability across the healthcare sector -in line with causal influences
- relevance of cases to current ecosystem dynamics
- technological based-interactions

The innovation ecosystems of the selected cases must have played or are currently playing a prominent role on the healthcare service delivery value chain with prime consideration of the accessibility of information and the interactions between ecosystem actors of the platforms. The selected case studies were significant in the following ways. The Mobile Alliance for Maternal Action (MAMA) and MomConnect platforms are both maternal health and education platforms. The uniqueness about this case which assist with the narratives is that they are well documented and additionally, MomConnect leveraged off MAMA as the program was handed over to the South African National Department of Health. The handover played a key role in the scaling of the technological intervention. The third platform, the District Health Information System 2 (DHIS2) intrigued the author by its ability to be deployed in over 60 developing countries and be integral to a country's Health Information System. The uniqueness was the strategic perspectives that went above just a sound technology.

This will also be the case in this study where the data sources are shown in Table 2.6.

Table 2.6: Data collection, Verification and Evaluation

<table>
<tr><th>Context
(Case Study)</th><th>Dissertation Stage</th><th>Method/Action</th><th>Data Sources</th><th>Dissertation Section</th></tr>
<tr><td rowspan="2">MAMA
&
MomConnect</td><td>Case Mapping
(SSM Stage 5)</td><td>Event Structure Analysis</td><td rowspan="2">• National Department of Health publications;
• Websites;
• Research Papers;
• Theses and Dissertations</td><td rowspan="2">Chapter 7</td></tr>
<tr><td>Preliminary Evaluation Stage
(SSM Stage 6 & 7)</td><td>Document Analysis
Grounded Theory</td></tr>
<tr><td>DHIS2</td><td>Case Mapping
(SSM Stage 5)</td><td>Event Structure Analysis Document Analysis
Grounded Theory</td><td>• Country-National Health Information Systems Strategies
• National DHIS2 reports & publications;
• UIO, DHIS2 websites;
• research papers, theses and dissertations</td><td>Appendix C;
Chapter 9</td></tr>
</table>

Context (Case Study)	**Dissertation Stage**	**Method/Action**	**Data Sources**	**Dissertation Section**
	Secondary Evaluation Stage ***(SSM Stage 6 & 7)***	**Stage 1**: Framework conceptualisation	• AfricaLICS fellowships at Aalborg University with innovation specialists from the Innovation Knowledge and Economics research group	Chapter 6
		Stage 2: Empirical data collection	• Semi-structured interviews *(20 Implementer interviews)* • Analysis of DHIS2 community forum	Chapter 8
		Stage 3: Data analysis		
		Stage 4: Framework amendments	• Semi-structured interviews *(3 subject matter expert interviews)*	Chapter 9

Each of the case studies yields insights that are relevant for that particular innovation ecosystem. Nevertheless, combining results from cross-case comparisons in order to strengthen results through replication (Yin, 2009). The main result of this synthesis is the identification of the attractors that can also be generically classified in the framework. Such a typology will be used as a basis to develop administrative and evaluative insights on the sustainability of healthcare innovation ecosystems.

The preliminary aspects of the Ecosystem Evolution and Emergence Framework (which will be referred to as the EEEF from this point onwards) were evaluated through the two mHealth applications called Mobile Alliance for Maternal Action (MAMA) and MomConnect in Chapter 8. The amended EEEF was evaluated by analysing the District Health Information System 2 (DHIS2) platform in Chapter 9. 18 semi-structured interviews with DHIS2 implementers and health management information officers were conducted to ascertain the soundness of the different blocks in the framework and to determine the key requirements that an innovation intermediary should consider in innovation ecosystems as well as other elements that might have been left out. Semi-structured interviews are more applicable for explorative studies and have an interview protocol to guide the researcher so that comparable data across the interview data is collected (Creswell, 2013). Qualitative interviewing offers the flexibility of capturing the interviewees' voices and experiences from the selected interview protocol (Rabionet, 2011). The protocol for this study was undertaken in contacting potential interview candidates via an explanatory email. Once the interview was scheduled, an introductory explanation was given outlining the background of the study and the reason for selecting the interview candidate was given.

The framework was further amended and then 3 expert interviews were conducted with Healthcare technology experts to see if any aspect was left out of the identified leverage points. Once the final framework was verified, conclusions and recommendations were drawn.

2.3.2 Ethical Considerations

This research adhered to Stellenbosch University's scholarly and scientific ethical guidelines under project number ING-2018-6442. The study was categorised under the category of minimal/low risk projects as no experiments were conducted on individuals and there was no access to confidential personal information neither was information gathered from vulnerable individuals. All interview participants were informed of the right to not participate in the study and had to consent to being interviewed. In order to get more truthful results, anonymity was maintained. The ethics clearance form can be found in Appendix E. Additionally, any study participants who were interested in the research findings will be sent a copy of the final write-up.

2.4 Chapter Conclusion

The overall research approach is shown in Figure 2.5 with the dissertation chapters that cover the aspects at various stages of the SSM to ensure that the research questions are fully addressed.

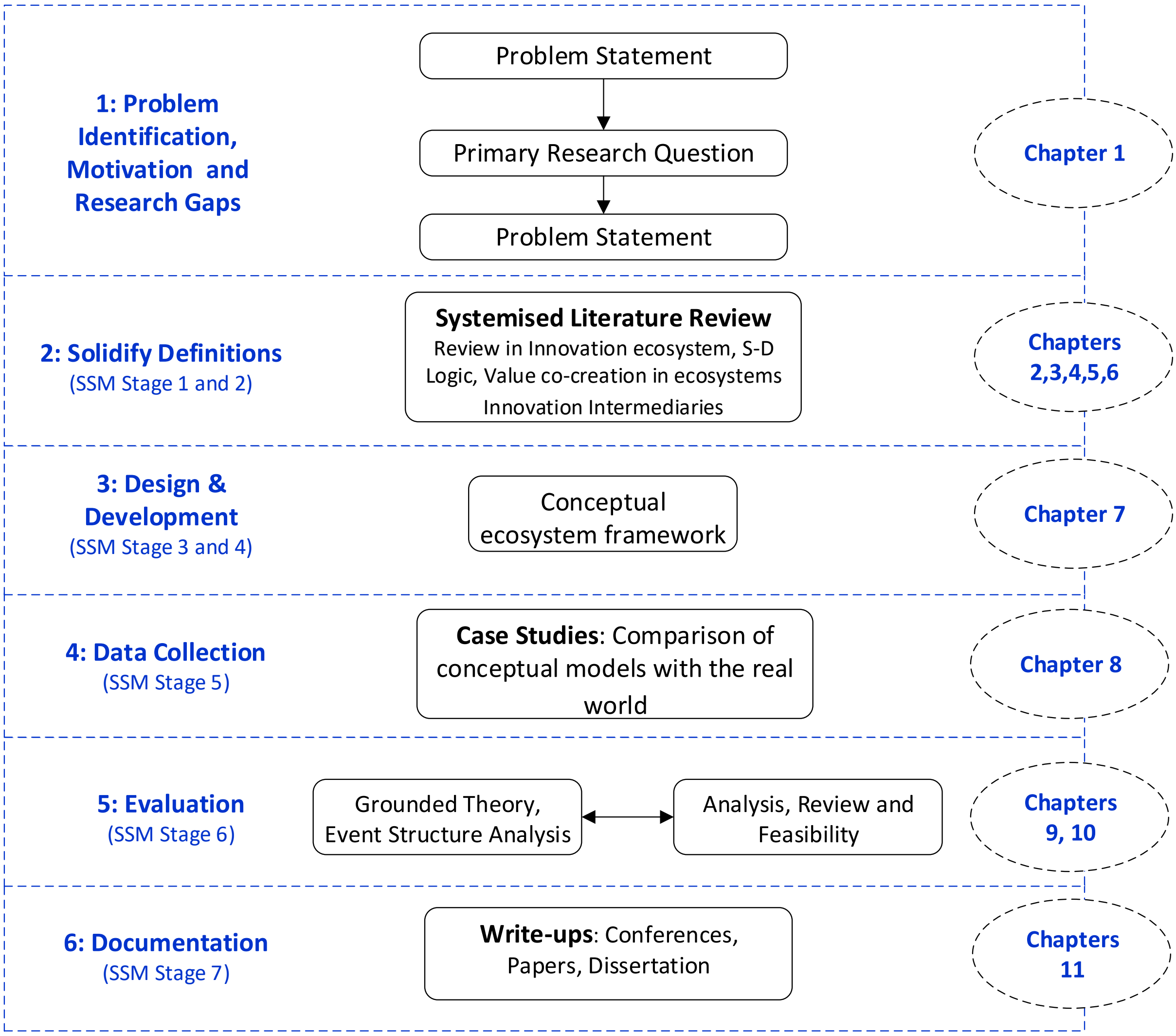

Figure 2.5: Overall Research Approach

This chapter discussed the research methodology that was used to answer the research questions posed in the study. SSM was outlined as both a directive and structuring aide that ensured the study had a logical structure due to the complexity involved. Event Structure Analysis was selected to thoroughly explore the case studies and make sure data was presented well. The ethical considerations that were applicable to the study were also presented.

The dissertation proceeds as follows: Chapter 3 outlines a review of relevant literature on innovation ecosystems and how innovation systems research stream can assist in understanding the dynamics of innovation ecosystems. Chapter 4 depicts how innovation ecosystems can be aligned to complex adaptive systems and how that can assist in how they are analysed. Chapter 5 then looks at why this study emphasises innovation intermediation for innovation ecosystem sustainability. Chapter 6 goes on to outline aspects of value and value co-creation in innovation ecosystems and particularly healthcare. The cumulative aspects from the literature review aligned with innovation ecosystems into an integrated framework and presented in Chapter 7. The empirical cases, data analysis and final edited framework are presented in Chapters 8, 9 and 10 respectively. Chapter 11 discusses the contributions, limitations and suggested future research areas that emanated from the study.

Chapter 3: Review of Innovation Ecosystems concepts

"*No company exists in a vacuum; each is part of an ecosystem.*" — Steven J. Bowen

This chapter defines and describe the (healthcare) innovation ecosystems concept. It goes on to outline how the innovation ecosystems construct differs from innovation systems and which complementarities exist. The alignment with SSM is shown in Figure 3.1.

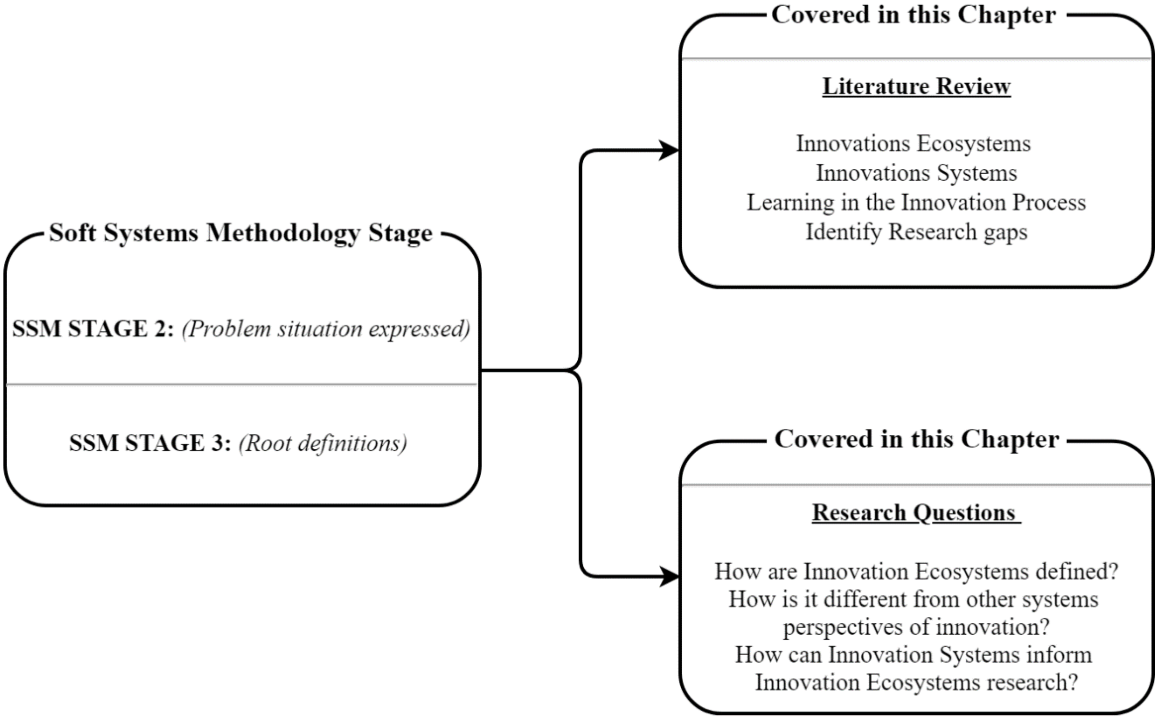

Figure 3.1: The Structure of Chapter 3 within the Context of the Soft Systems Methodology.

3.1 Innovation Ecosystems

3.1.1 Definitions of Innovation Ecosystems

The definitions of an innovation ecosystem have been centred around four main aspects - the actors in the ecosystem, the functional goal of the ecosystem, the focal aspect (artefacts) of the ecosystem and the formation process (Adner, 2017; Autio & Thomas, 2014; Els, Grobbelaar & Kennon, 2018; Jackson, 2011).

Jackson (2011) defined an innovation ecosystem as "*the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation.* " (Jackson, 2011: 2). Jackson pointed out how a functional goal is important whilst acknowledging the complex relationships that arise from addressing that goal. Autio and Thomas (2014) went on to refine Jackson's definition through a review they undertook by adding that an ecosystem has a focal point as it is "*a network of interconnected organizations, organized around a focal firm or a platform, and incorporating both production and use side participants, and focusing on the development of new value through innovation*" (Autio & Thomas, 2014: 3). Bogers, Sims and West highlighted the interdependency and self-interest of the actors by outlining an innovation ecosystem as "*an interdependent network of self-*

interested actors jointly creating value" (Bogers *et al.*, 2019: 2). The interdependence can be mostly considered technological (around modularity and platforms), economic and cognitive[6]. Thomas and Autio (2020) proposed a definition that cements the elements of interdependence but added a structural aspect by describing an ecosystem as "*a community of hierarchically independent, yet interdependent heterogeneous participants who collectively generate an ecosystem output*" (Thomas & Autio, 2020: 30). This emphasis is on the aspects that have dependency and interdependency in the ecosystem shows that the field is slowly coming to a consensus on the aspects to look at to better understand ecosystems. Granstrand and Holgersson (2019) added an element of how the constituency of innovation ecosystems changes temporally by highlighting that an innovation ecosystem "*is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors*" (Granstrand & Holgersson, 2019). This interdependence was further categorised to three forms, namely, technological, economic and cognitive (Thomas & Autio, 2020).

The focal aspect of the ecosystem has spurred different ecosystem constructs such as business ecosystems (Moore, 1993), platform ecosystems (Gawer & Cusumano, 2014; Herman, 2019; Ngongoni *et al.*, 2018a), entrepreneurial ecosystems (Auerswald, 2014; Ngongoni & Grobbelaar, 2017; Prahalad & Ramaswamy, 2004; Spigel, 2015b) and healthcare digital innovation ecosystems (Iyawa, 2017; Phillips *et al.*, 2017). When it comes to the functional goal, Els et al (2018) categorised ecosystems according to the value appropriated by the ecosystem from a relational perspective. The categories were integration ecosystems (business integration to offer a service), collection ecosystems (portals of information), matching ecosystems (match producers and users), data collection ecosystems (platforms that source data from users) and sequenced ecosystems (key value offering built around series of sequential events) (Els *et al.*, 2018). Categorising ecosystems in this way decreases the emphasis on the operational sector or focal point but rather on the value creation and relational aspects of actors aligned with context, configuration and cooperation (Autio & Thomas, 2014; Moore, 1993; Scaringella & Radziwon, 2017).

Though Adner did not digress from the basic definition of innovation ecosystems by defining an innovation ecosystem as "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize"*(Adner, 2017: 40), Adner did highlight a differentiation based on how they are formed. The emphasis was on how innovation ecosystems can be categorised primarily as emerging from affiliation or structure. The *"ecosystem-as-affiliation"* construct exemplified how traditional boundaries are broken down giving rise to interdependence and symbiotic relationships. The associated actors are defined by their network affiliations and levels of openness which is helpful when it comes to looking at the ecosystem actors' interactions at a macro level (Adner, 2017). On the other hand, *"ecosystem-as-structure"* is when an innovation ecosystem starts with a value proposition and seeks to identify and configure the set of actors that are needed in order for the value

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[6] Working paper from Autio and Thomas

proposition to become a reality (Adner, 2017; Adner & Kapoor, 2010; Autio & Thomas, 2014). In this definition, Adner sought to clarify how members of an ecosystem have defined positions and activity flows especially as the actors have different end-goals in mind. Thus innovation ecosystems may be treated as a mixture of business networks and communities for innovation (Smorodinskaya *et al.*, 2017). The ecosystem approach all depends on the challenge at hand. A summary of the types of ecosystems grouped according to the two constructs proposed by Adner is shown in Figure 3.2.

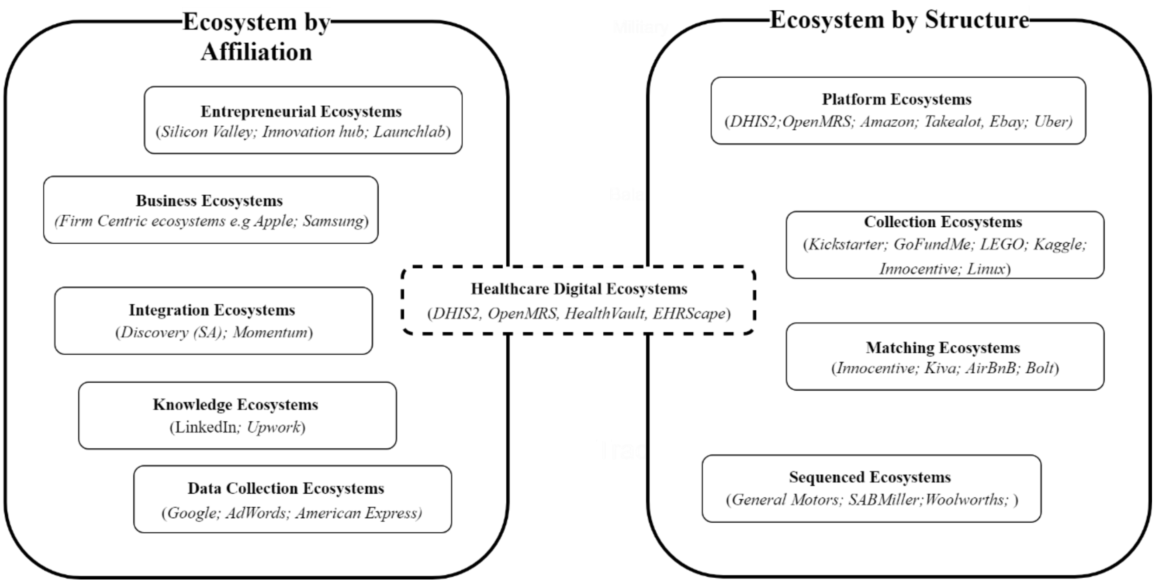

Figure 3.2: Innovation Ecosystems Alignments, extracted from (Adner, 2017; Els *et al.*, 2018; Gawer & Cusumano, 2014)

There are a number of factors that need to come together in order for the value of an innovation to be realised (Adner & Euchner, 2014). Not only is there a need to satisfy end-users, facilitate innovation and manage the interaction with the innovation ecosystem but to also ensure that the individual actors achieve their own organisational goals (Adner & Euchner, 2014). Bogers et al.(2019) undertook a review cumulatively looking at the proposed definitions founded on work undertaken in ecosystems research. Through the review they offer a foundational definition that links three operational constructs (interdependence, network and self-interested actors) to the joint creation of value and offering a review of ecosystems research (Bogers *et al.*, 2019). This gave ground to the relations among constructs in the ecosystem concept depicted in Figure 3.3 below.

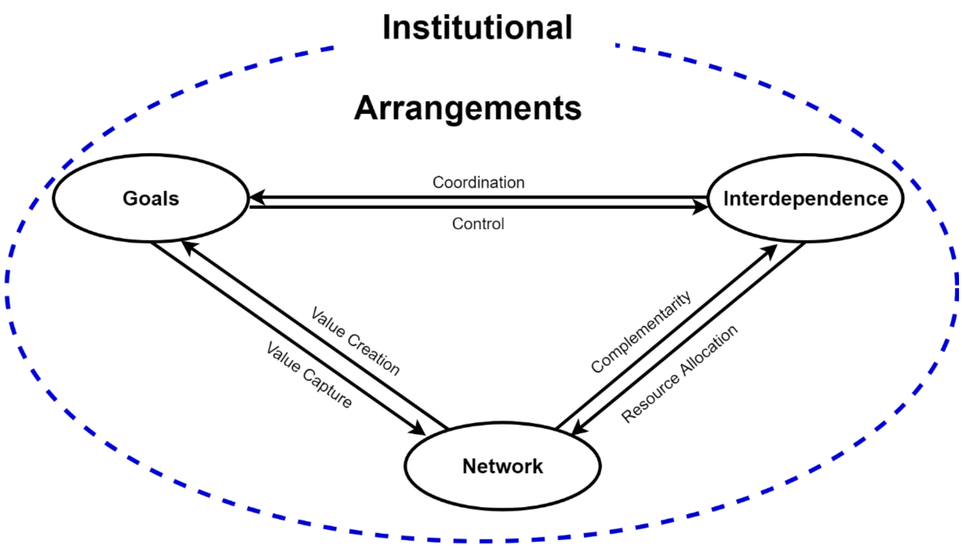

Figure 3.3: Innovation Ecosystems Operational Constructs

However, in addressing the constructs, Bogers et al. (2019) seemed to emphasise more on the structural arrangements of innovation ecosystems and less on the acknowledgment of the key role that institutions and institutional arrangements play (shown by the dotted blue line in Figure 3.3). Thus, Thomas and Autio's (2012) summary of ecosystem characteristics as value logics, institutional stability and participant symbiosis makes it more holistic. *Value logics* pertain to how value is co-created in the ecosystem. Adaptation and evolution are key attributes of an ecosystem and actor relationships must be symbiotic as members co-evolve for ecosystem survival and value creation (Iansiti & Levien, 2004; Moore, 1993). *Participant symbiosis* is structured around the benefits obtained from the complementary nature of the actors which means that through interactions in the ecosystems this can lead to superior individual performance for the actors (Thomas & Autio, 2012). Since an important attribute of innovation ecosystems is the coupling between the tangible and intangible resources, an innovation ecosystem is deemed to be thriving when resources invested into the ecosystem amongst actors translate into innovative activities and commercial value (Jackson, 2011). *Institutional stability* relates to how the ecosystem is governed which is driven through *the firm (actor) level locus of coordination* (Thomas & Autio, 2012). These three aspects are shown in Figure 3.4.

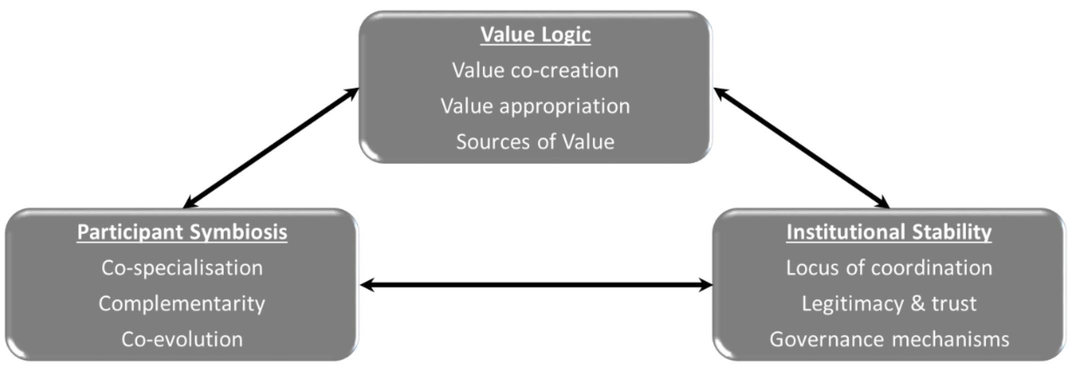

Figure 3.4: Ecosystem characteristics Source: (Thomas & Autio, 2012)

Adding Bogers et al. (2019) and Thomas and Autio's (2012) perspective aids in emphasising institutional arrangements as well as the interdependency of the actors with their own self-interest. These distinctions are important to note as this builds grounds for moving past merely exploring structural arrangements but also considering knowledge and learning dimensions.

3.1.2 Attributes of Innovation Ecosystems

The innovation ecosystems construct has been linked to other theoretical constructs aimed at explaining innovation activity and processes. Such constructs linked with regions are agglomeration economics, innovation systems, networks and cluster literature. Distinguishing innovation ecosystems from other innovation system related constructs is not an easy task as various definitions of innovation ecosystems still exist (Autio & Thomas, 2014; Ritala & Almpanopoulou, 2017; Ritala & Gustafsson, 2018; Thomas & Autio, 2014). Nevertheless there are some distinctions which can be made from aspects such as the systematic functioning of the system and governance mechanisms (Thomas & Autio, 2020), the usage of open innovation and the value propositions of the constructs (Oh *et al.*, 2016; Thomas & Autio, 2020).

Building on innovation ecosystem definitions mentioned above comes the first structural distinguishing feature of innovation ecosystems. An innovation ecosystem construct was identified to have three core characteristics: a network of participants, a non-contractual governance system, a shared logic (Autio & Thomas, 2014; Thomas & Autio, 2020).

Ecosystem participants are organised either around a focal hub (Moore, 1993), firm (Adner & Kapoor, 2010), technology (Jackson, 2011) or platform (Thomas *et al.*, 2014) whereas clustered firms or regional innovation systems are centred upon geographically co-located firms in the same industry which supplement each other's supply chain in order to meet a demand (Porter, 1998). In cases like entrepreneurial ecosystems which seem to be built around proximity-related resources such as accelerators or incubators, another level of differentiation comes from the notion of digital and spatial affordances (Autio, Nambisan, Thomas, *et al.*, 2018). Digital affordances are aligned with digital technologies and infrastructures. The ecosystem is therefore brought together by the functional purpose with actors from various industries to address a common goal (Jackson, 2011; Oh *et al.*, 2016). These innovation ecosystem actors include entities involved in the focal firm's value chain, as well as its customers – which is both a form of horizontal and vertical integration. Thomas & Autio (2020) alluded to ecosystems conceptual proliferation emanating from the spatial and non-spatial levels or units of analysis and the types of outputs from the ecosystem. The spatial levels of analysis can be aligned with the local (suburban, city), national, regional, or global levels and the non-spatial levels focus more on the focal firms and their complementors, platforms and their complementors and industry-wide.

Thus, in an ecosystem, firms are more likely to be brought together through sharing some core technology, knowledge, experience or through facing the same challenges which is from collective functionality rather than just being in the same industry (Spigel, 2015a). Autio and Thomas (2014) go further to state that " *Instead of thinking about ecosystems as an industry, it is more useful to think about ecosystems as an evolving community that specializes in the development, discovery, delivery, and deployment of evolving applications that exploit a* *shared set of complementary technologies and skills*" (Autio & Thomas, 2014: 7). It has been noted that ecosystems offer a systems approach to innovation where the actors concentrate on their own competitive advantage whilst still being an integral player in the ecosystem (Suominen *et al.*, 2019).

More explicitly, an innovation ecosystem – due to its analogy with biological ecosystems – has been deemed a complex adaptive system (CAS). This is a system that consists of actors that mutate and responds to stimuli imposed by the environment (Arora, 2016; Shaw & Allen, 2018). This highlights the self-organisation, self-governance and emergence of ecosystems as they evolve in response to inputs from participants, who complement one another through symbiosis and learning, and as a response to exogenous stimuli (Arora, 2016). Notably this is not the first reference to the application of complex adaptive systems to other streams of innovation-related research such as agglomeration economics or innovation systems to explain their networks. The self-organisation of complex systems is associated with the uncertainty of business operating environments where technology and consumer requirements change at a rapidly increasing pace. Thus, in CAS the actors collaborate and compete in order to offer tangible and intangible benefits to the ecosystem and create value which is what innovation ecosystems adhere to (Shaw & Allen, 2018; Suominen *et al.*, 2019).

In regional innovation systems or clusters, there tends to be defined structural arrangements and boundaries with clear authoritative figures. In innovation systems these are known as innovation system builders (Musiolik, Markard, Hekkert, *et al.*, 2018). However, for innovation ecosystems boundaries are a bit difficult to define as there are diverse actors stemming from outside the traditional value chain (Autio & Thomas, 2014; Oh *et al.*, 2016). The diversity of actors reinforces the notion that ecosystems are at risk of not being sustainable or the construct not practically feasible due to lack of clearly defined roles when it comes to the management and coordination for value creation in the ecosystem. This has seen some studies aim at describing the roles that apply to an innovation ecosystem and how they aid in value creation (De Silva *et al.*, 2018; Pittaway & Autio, 2017; Shaw & Allen, 2018). One suggestion is that value creation can be achieved through a managed mediation service or an intermediary (Thomas & Autio, 2014).

The inclusion of users/customers in the value chain gives the third distinction of the innovation ecosystems construct from other network constructs such as clusters and industry networks which focus solely on just the production side or user networks. The ecosystem incorporates both the user and production side of the value chain (Autio & Thomas, 2014; Spigel, 2015a). Merging the supplier and customer networks facilitates processes that are focused on co-creation of value rather than just products and services, and in ecosystems research, this goes further to focus on the appropriation of such value as the ecosystem participants co-evolve to support customer innovation needs thorough collaboration and competition (Adner, 2006; Agogué *et al.*, 2013; Moore, 1993; den Ouden, 2012). Hence this creates value for the firm that no individual firm could have accomplished alone (Porter & Kramer, 2011). Ecosystems tend to have non-linear relationships where the primary focus is not just on the optimisation of current networks but also how they evolve towards new states (Autio & Thomas, 2014). This is closely linked to the innovation systems concept that looks at how economies are affected by innovative activities from government, industry, education and citizens (Chaminade, Lundvall & Haneef, 2018; Lundvall, Vang, Joseph, *et al.*, 2009). So one major differentiating factor between using the innovation ecosystems and innovation systems lenses is that the lens of ecosystems in its design and evolution is made for interactive co-creation of value, while an innovation systems lens does not necessarily acknowledge this (Autio & Thomas, 2014; Jackson, 2011; Smorodinskaya *et al.*, 2017).

Though the innovation ecosystem construct has been suggested to be an insightful way of viewing and analysing how organisations interact, collaborate and cooperate in a sustainable way, the term is still faced with a high level of uncertainty and critique.

3.1.3 Innovation Ecosystems Construct Critique

The 'ecosystems construct' has come under a lot of scrutiny particularly due to conceptual ambiguity, methodological challenges and a lack of a rigorous foundation (Oh *et al.*, 2016; Ritala & Gustafsson, 2018). This is largely due to the reasoning that the innovation ecosystem concept is not yet clearly defined and has ambiguous terminologies. Moreover, terms of different types of ecosystems are often used interchangeably with not enough theory testing (Schreieck *et al.*, 2016; Smorodinskaya *et al.*, 2017). An example of taxonomic ambiguity is when Yawson described what he termed an 'ecological system of innovation' which can be missed if one is searching for just the term innovation ecosystem (Yawson, 2009). Oh et al. (2016) published a critical review questioning whether there are any gains from aligning innovation with the biological construct of an ecosystem. In the review Oh et al. (2016) do acknowledge that though 'eco' literature does make positive contributions, such contributions are in no way aligned to the ecosystems construct as the usage of the construct is more metaphorical and poorly developed.

As a first argument Oh et al. (2016) noted that an innovation ecosystem is not an evolved entity, but it is designed. Though this may be considered a valid argument, in the face of new market forces and disruptive technologies an ecosystem actually evolves from the designed state to another state just as a natural ecological ecosystem would in order to survive (Jackson, 2011). Moreover, the 'eco' notion stands to emphasise the non-linear nature of the collaborations that occur for innovation (Jackson, 2011; Ritala & Almpanopoulou, 2017). Oh et al. (2016) concluded that the term 'ecosystem' does not offer any novel ways of thinking when it comes to innovation and that the risks outweigh the benefits of such alignment (Oh *et al.*, 2016). The argument is that the ecosystem construct has been used metaphorically in describing the interconnectedness of innovation and entrepreneurship, whilst drawing phenomena explanations from other theoretical foundations (Ritala & Gustafsson, 2018).

When it comes to related theoretical foundations, of note is how the "innovation ecosystem" construct seems identical to the ''innovation system'' construct. However, some of the main supporters of the innovation systems construct such as Lundvall acknowledge that there is a difference between innovation systems and innovation ecosystems especially on the aspect of collaborative value creation (Chaminade *et al.*, 2018). This study did not aim to differentiate the two constructs but does use the sound theoretical base of innovation systems in order to inform innovation ecosystems research. The innovation systems construct is used to help explore and understand how the dynamics in innovation ecosystems can be analysed and explained.

Such sentiments have garnered a number of responses from ecosystems advocates with different stand points (Ritala & Almpanopoulou, 2017; Ritala & Gustafsson, 2018). Though they do understand where critique of ecosystems holds weight, there have been recent studies that have digressed from just aligning definitions and structure with examples to consider the ecosystem construct (Cibat, Süße & Wilkens, 2017; Durst & Poutanen, 2013; Gatarik, Janosova, Jirasek, *et al.*, 2015). These studies have the aim of ascertaining the evolutionary characteristics of the ecosystem and they assess how value is created in this ecosystem (Pittaway & Autio, 2017; Thomas & Autio, 2012). Smorodinskaya *et al* (2017) realised that "*In the age of non-linear innovation and digital technologies, innovation can be better nurtured within a special, innovation-conducive environment. Such an environment may be seen as an ecosystem meant for co-creation of value through collaboration*" (Smorodinskaya *et al.*, 2017: 3).

Durst and Poutanen (2013) highlighted that the successful implementation of innovation ecosystems is centred around resources, governance, organisational culture, strategy and leadership, people partners, technology, human resources management and clustering. Notably, this is nothing new when it comes to constructs that have a socio-technical perspective like innovation ecosystems but of note is how these aspects are managed in order to ensure the longevity and relevance of the ecosystem. Adner (2014) suggests that after ascertaining that there is an innovation that needs to be disseminated, then a *minimum viable ecosystem* should be put forward in order to manage a staged expansion where addition of any ecosystem actors adds to the value proposition. As innovativeness is a characteristic of culture – which is a critical element of innovation ecosystems – this quality cannot be created but can be transformed by purposeful action (Wallner & Menrad, 2011).

Aspects around the way the ecosystem concept is perceived, how research is conducted, the theoretical foundations and tools to study ecosystems empirically were highlighted by researchers as important aspects in furthering 'ecosystems' research (Ritala & Gustafsson, 2018). Hence, in agreement with all the highlighted gaps that Oh et al., (2016) and other ecosystem advocates pointed out, this study offers an alternative methodology that assists in ecosystem management and theory building. During the course of this study the author attended the 2019 edition of the Danish Research Unit for Industrial Dynamics (DRUID) conference where substantial thought-provoking work on innovation ecosystems has been presented (Thomas & Autio, 2012, 2014). There was an interesting debate on the relevance of the consideration of the ecosystems construct when it comes to research aligned with economics, innovation systems and entrepreneurship and there were clear points made by Gawer and Cusumano on the importance of incorporating an ecosystems perspective in management research [7].

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[7] Druid conference Ecosystem debate link: https://vimeo.com/345408826

3.1.4 Advancing the Innovation Ecosystems Discourse

Building from the critique above, the research gaps aligned with innovation ecosystems centre around core ecosystem constructs, theory building, network structure, governance (*coordination, collaboration*), value creation/capture, regulation, goals of ecosystem members, understanding ecosystem emergence and interdependence between members.

a) *Core ecosystem constructs* - The aspect of innovation ecosystems missing substantial and validated theoretical models and frameworks is one that has been raised in various reviews that outline the pace of research in the field and identify research gaps (Gawer & Cusumano, 2014; Smorodinskaya *et al.*, 2017; Thomas & Autio, 2012; Thomas *et al.*, 2014; Tsujimoto, Kajikawa, Tomita, *et al.*, 2015; Valkokari, 2015). This is understandable as there is a lack of coherence in the definition and consistency in the application of the innovation ecosystems construct (Autio & Thomas, 2014; Oh *et al.*, 2016; Ritala & Almpanopoulou, 2017; Ritala & Gustafsson, 2018). Though this is essential, just as everything grows and evolves to the next stage, there is now emphasis on addressing how the competency building of ecosystems aligns with institutions, organisational culture and strategy (Oh *et al.*, 2016). Jacobides et al (2018), Bogers et al (2019) and Autio & Thomas (2019) suggested making the ecosystem a unit of analysis and not differentiation amongst the different ecosystems types. This is in order to move past phenomenon-centred research and instead concentrate on the comparability, generalisability and conditionality of empirical studies, allowing a better connection to the original concept of the biological analogy. An in-depth summary for some of these reviews is in Appendix A. Several studies aimed at addressing the technological aspects and structure of innovation ecosystems as a step in solidifying the concept.

b) *Theory building* - Under the notion of not re-inventing the wheel, integrating ecosystem research with existing schools-of-thought is suggested as a progressive way to further ecosystems research. This has seen studies align with theoretical foundations with systems thinking, CAS, network theory and social networks to provide explanations of different dynamics in ecosystems (Ritala & Gustafsson, 2018; Valkokari, Seppänen, Mäntylä, *et al.*, 2017). Other scholars suggest models of how to represent innovation ecosystems. Yawson (2009) suggested using system dynamics to model an innovation ecosystem that allows time lags, interaction of various factors and formal computer simulations of complex relationships. The study utilised a hybrid of the Delphi method, balanced scorecard, quadruple helix theory and analytical hierarchy process in an attempt to offer a functional evidence-based platform for science and innovation policy. However, Yawson (2009) acknowledged that such modelling still assumes a calculable cause-effect relationship which can be mechanistic. Nevertheless, modelling innovation ecosystems, especially with the advancement of data analytics gives a way to proactively plan and arrange innovation ecosystems, hence it is a key research direction (Järvi & Kortelainen, 2017; Tsujimoto *et al.*, 2015). Such modelling has been introduced through studies that looked at agent-based modelling of ecosystems. Other scholars have resorted to aligning and comparing how the innovation ecosystems construct relates to other theories such as value chains (Dondofema & Grobbelaar, 2019), innovation systems (Scaringella & Radziwon, 2017; Smorodinskaya *et al.*, 2017; Suominen *et al.*, 2019). Comparisons are also a good way of building complementarity and cementing distinctions between the differences of innovation ecosystems and other concepts.

c) *Ecosystem emergence* - The ecosystems theory building and testing aligns well with understanding how the ecosystems emerge and is of paramount importance for cementing the construct (Gawer & Cusumano, 2014; Jacobides *et al.*, 2018; Thomas & Autio, 2014). Such theoretical constructs aim to go beyond metaphoric symbolisms and assist in better understanding of ecosystems. With ecosystems also comes the aspect of prevalent research methodologies such as action research and design science that look at how the ecosystem is built (Braa & Sahay, 2012; Herselman & Botha, 2017; Tsujimoto *et al.*, 2015; Valkokari *et al.*, 2017). Due to the limited understanding of the structures and practices that support value co-creation in innovation ecosystems, a structuralist approach for conceptualising the ecosystem construct has been proposed (Adner, 2017; Ketonen-Oksi & Valkokari, 2019). However, for the aspects related to longevity and the sustainability of the ecosystem, reflective research methodologies (looking at the historical analysis) are essential. Hence, we suggest the use of SSM and alignment with CAS as a means of understanding how ecosystems emerge and evolve.

d) *Value Creation/Capture and Goals of ecosystems members* - Diverting from the theoretical aspects to the management dynamics, end-users/customers have been lobbied to be core contributors to the value co-creation in the ecosystem (Jacobides *et al.*, 2018; Pittaway & Autio, 2017; Schreieck *et al.*, 2016). This works well when considering inclusive ecosystems that aim at social innovation and inclusion in resource constrained environments such as Innovation for Inclusive Development (I4ID) (Aarikka-Stenroos *et al.*, 2016; van der Merwe *et al.*, 2020; van der Merwe & Grobbelaar, 2018). Nevertheless, some suggestions go against collective analysis of ecosystems and lobby for an in-depth analysis of participants individually and how being part of an ecosystem affects actors distinctly which assists ecosystem management (Schreieck *et al.*, 2016). This has been more apparent in entrepreneurial ecosystems where the entrepreneurs by being part of an ecosystem increase their legitimacy and access to resources (Ngongoni, 2016; Spigel, 2015b). Innovation management literature has a more increased focus on collaborative practices of value creation (Järvi & Kortelainen, 2017; Lee, Park, Yoon, *et al.*, 2010; Vargo *et al.*, 2016). Ketonen-Oksi & Valkokari (2019) ascertain that a greater effort is needed from researchers across different fields to empirically test and re-conceptualise the fit that occurs between theoretical foundations and value co-creation. Overall, the dynamics of how value is created and appropriated in an ecosystem is still an enigma as it is also difficult to assess and measure when value has been successfully appropriated (Aarikka-Stenroos *et al.*, 2016; Adner & Kapoor, 2010; Adner Ron & Kapoor Rahul, 2016; Bogers *et al.*, 2019; Gomes *et al.*, 2018).

e) *Governance* - Innovation ecosystems management aligned with coordination and collaboration is of paramount importance as clear aspects of multiple-actor oriented innovation still remains limited (Barile, Lusch, Saviano, *et al.*, 2016; Järvi & Kortelainen, 2017; Suominen *et al.*, 2019). As the ecosystem actors usually aim for their individual interests in the process of co-creating the end goal of the ecosystem, there is need for a management structure that also aligns with the overall direction of the ecosystem and aware of how to move from one stage to the next strategically. With different ecosystems utilising some form of technological component, looking at how the usage and roles of technology changes plays a role in ecosystem management is one valid focus area (Aarikka-Stenroos *et al.*, 2016). Such an example is how data can now be utilised as a boundary resource especially in this age of predictive data analytics (Oh *et al.*, 2016; Schreieck *et al.*, 2016). One of the main contentious issues in innovation ecosystems is around governance dynamics (Oh et al., 2016; Ritala and Gustafsson, 2018). If the 'ecosystems' construct is to be taken literally then there is no need for an intermediary. But even in natural ecosystems there is a lead or core species that dramatically affects the dynamics of the ecosystem; hence an intermediary of sorts is important for purposeful innovation to occur.

f) *Institutions (Regulation)* – The importance of institutions aligned with spurring collaboration and protecting actors in innovation ecosystems is important. Striking a balance between the needs of the main innovation ecosystem builder and the other ecosystem actors is of vital importance. In an ecosystem with multiple actors, co-creation of value becomes a continually active and reiterative process between producers and to achieve a common vision, strategy and identity (Smorodinskaya *et al.*, 2017). Effective collaboration and cooperation require a high level of trust and this all stems from an institutional perspective (Thomas & Autio, 2012). The role of the government is key, and it cannot be monolithic as innovation ecosystems are now increasing reliant on technology based interventions, and collaboration is on technology platforms. With regards to platforms it is important for the government to be involved as the platform supports the core interaction between users and producers that spurs value creation and capture (Korhonen, Still, Seppänen, *et al.*, 2017).

Furthermore, linking industry and the educational sector or research organisations is important as capacity and competence building are all key things that lack, especially in resource constrained environments. Notably, education policies and curriculum should also be proactive in ensuring that curriculums are matched with industry needs. In the case of DHIS2 adding an educational component to the ecosystem spurred increased network effects which is fundamentally what is important when it comes to technology dissemination (Braa & Sahay, 2012).

g) *Measurement of Ecosystem Dynamics* – Valid measures for the linkages between the different ecosystem aspects of an innovation ecosystem namely, the value logics, participant symbiosis and institutional stability tend to increase the internal and external validity of innovation ecosystem research (Bogers *et al.*, 2019; Ritala, Agouridas, Assimakopoulos, *et al.*, 2013). Value creation is difficult to measure in practice: at best, qualitative ecosystem studies have offered observations or predictions of value creation without measurement. These measures can constitute operationalisation of market shares or total revenues from the ecosystem sales to represent the total (monetary) value created in the ecosystem (Bogers *et al.*, 2019). Another suggestion is looking at the frequency of interactions between specific ecosystem actors. The supposition is that maybe the frequency of these interactions is of significance and is a measure of the nature and quality of these relationships in order to accurately determine how tangible and intangible value is created, shared and transferred, enabling the coproduction of new goods and services (Smorodinskaya *et al.*, 2017). However, such suggestions tend to divert focus from intangible forms of values which are important to getting a holistic picture.

The overall research gaps that were identified from innovation ecosystems literature are shown in Table 3.1.

Table 3.1: Innovation Ecosystems Research Gaps

ASPECT	SUGGESTED RESEARCH	REFERENCES
DEFINITION OF INNOVATION ECOSYSTEMS	– consolidated definition for referral purposes	(Jacobides *et al.*, 2018; Ritala & Gustafsson, 2018)
EMERGENCE	– investigation of how ecosystems emerge and are created – look at aspects of ecology to inform aspects of artificial ecosystems	(Autio & Thomas, 2014; Gawer & Cusumano, 2014; Oh *et al.*, 2016; Thomas *et al.*, 2014)
EVOLUTION	– understand how ecosystems evolve from one stage to the next stage – understand how technology evolves in an ecosystem	(Aarikka-Stenroos *et al.*, 2016; Gawer & Cusumano, 2014)
TECHNOLOGY IMPACT	– understanding impact of technology on innovation and competition particularly non-incremental innovation – integration of market and technology-oriented perspectives – inform how platforms affect ecosystem development – investigate how technology and agent roles change over time in an ecosystem and the roles of agents in this process	(Aarikka-Stenroos *et al.*, 2016; Gawer & Cusumano, 2014; Gomes *et al.*, 2018)
THEORY AND FRAMEWORK TESTING	– expansion of current theoretical models and frameworks – use of action research on the building of a new ecosystem – how platforms evolve	(Pittaway & Autio, 2017; Thomas *et al.*, 2014; Tsujimoto *et al.*, 2015)
COMPARISON WITH OTHER CONSTRUCTS	– discerning differences of innovation ecosystems from other innovation and networking constructs – consider other theories such as institutional theory, game theory and decision-making for ecosystem research	(Jacobides *et al.*, 2018; Oh *et al.*, 2016; Ritala & Gustafsson, 2018)
ECOSYSTEM PARTICIPANT ANALYSIS	– examination of the components proposed in the conceptual framework have been applied in developed and developing counties	(Iyawa *et al.*, 2016; Schreieck *et al.*, 2016)
BUSINESS MODEL DYNAMICS	– focus on business model dynamics when it comes to ecosystems – understand new business models of partnership between private and public	(Aarikka-Stenroos *et al.*, 2016; Pittaway & Autio, 2017)
DATA AS A RESOURCE	– study data as a boundary resource	(Schreieck *et al.*, 2016)

ASPECT	SUGGESTED RESEARCH	REFERENCES
VALUE CREATION, CAPTURE AND APPROPRIATION	− theorising customer involvement in value creation − how is value created and delivered within the ecosystem? how much will be based on services, tangible and intangible assets? − how much of the value is co-produced at the point of use or transferrable?	(Autio & Thomas, 2014; Gomes *et al.*, 2018; Pittaway & Autio, 2017; Thomas & Autio, 2012)
VALUE EXTERNALITIES	− look at how external networks influence the value creation process	(Autio & Thomas, 2014)
STRATEGIC MANAGEMENT /ECOSYSTEM STRATEGY	− practitioner implications for ecosystem strategic management − look at non-technological aspects such as strategy, culture, organisation and institution to build competency of ecosystems − how do firms manage partners in an ecosystem? − how to manage the innovation integration across the ecosystem − dynamic capabilities through ecosystems − resource based view of ecosystems	(Aarikka-Stenroos *et al.*, 2016; Autio & Thomas, 2014; Gomes *et al.*, 2018; Oh *et al.*, 2016)
CONTROL MECHANISMS	− investigate control migration as ecosystems evolve so does the critical control mechanisms so firms need to proactively plan	(Autio & Thomas, 2014; Thomas & Autio, 2012)
METRICS	− finding metrics for innovation ecosystem performance	(Oh *et al.*, 2016)
ECOSYSTEM LEADERSHIP	− explain how a firm becomes a leader of an industry platform, − which organisational processes are used to implement and manage ecosystems	(Gomes *et al.*, 2018)
BOUNDARY LOGICS	− understanding boundaries of ecosystems	(Autio & Thomas, 2014; Thomas & Autio, 2012)
VENTURE CREATION	− how do new ventures influence the ecosystem; how do entrepreneurs build an ecosystem to create value to customers	(Gomes *et al.*, 2018)
EMERGENT INDUSTRY	− cross industry analysis; analysis of industrial change; mature ecosystems vs. ecosystems of emerging markets	(Aarikka-Stenroos *et al.*, 2016; Iyawa *et al.*, 2016)
INNOVATION ECOSYSTEMS DIFFERENTIATION	− Clarifying how innovation ecosystems differ from innovation systems − Clarifying how ecosystems can be differentiated using the unit of analysis and structural aspects	(Oh *et al.*, 2016) (Thomas & Autio, 2020)

3.2 Innovation Systems

An innovation system (IS) is defined as an "*an open, evolving and complex system that encompasses relationships within and between organizations, institutions and socioeconomic structures which determine the rate and direction of innovation and competence-building emanating from processes of science-based and experience-based learning*" (Lundvall *et al.*, 2009: 7). The concept was established upon the insight that national economic growth and innovation is an interactive process that is not only reliant on technological advancement but also on other factors. These factors include education and training institutions, knowledge productions and accumulation, user-producer interactive learning strategies, networks and institutions (Chaminade *et al.*, 2018; Freeman, 1995; Lundvall, 2007). Organisations are embedded in a socio-economic system where innovative activities are affected by cultural, political effects and economic policies (Freeman, 1995). The focus was mainly on the determinants of innovation and not the social consequences such as working conditions and unemployment (Edquist, 2001). In IS there are two main meanings of institutions; either different kinds of organisations or the common rules, laws and routines that regulate relations and interactions (Edquist, 2001; Edquist & Johnson, 1996). In this study the latter meaning was the point of reference.

The innovation systems construct has been pointed out to be the most closely aligned theoretical concept to innovation ecosystems (Oh *et al.*, 2016; Ritala & Almpanopoulou, 2017; Ritala & Gustafsson, 2018). However, Mercan and Goktas (2011) purport that the innovation ecosystems approach is noted to give a distinction between innovation events and innovation structure, which lacks in the systems of innovation approach. Moreover the innovation systems construct has a static nature compared with the dynamic nature of innovation ecosystems that is guided by new needs of the ecosystem and circumstances (Mercan & Goktas, 2011). There are several calls to distinctly show the uniqueness of innovation ecosystems as compared to other constructs this study aligned with the suggestions by ecosystems' advocates to use other theoretical aspects (in this context innovation systems and knowledge management) to explain the innovation ecosystems construct (Ritala & Gustafsson, 2018). The reason for this was to divert focus from just defining innovation ecosystems or outlining structural and architectural components of innovation ecosystems which has already been done by other studies (Iyawa *et al.*, 2016; Parker *et al.*, 2016; Smorodinskaya *et al.*, 2017; Thomas & Autio, 2012). Instead it is to add to conceptualisation, theory building and testing that is assisted by other established research theories such as CAS and innovation systems.

3.2.1 Types of Innovative Systems

Innovation systems have primarily been differentiated on levels aligned with country analysis (national), regional areas, industrial sectors , technology and more recently, globally (Carlsson & Stankiewicz, 1991; Chaminade *et al.*, 2018; Lundvall, 2007; Lundvall *et al.*, 2009).

National Innovation Systems were the foundational concept that came from evolutionary economists due to scholars seeking other explanations to what determines economic growth and international competitiveness amongst nations (Lundvall, 2007). This highlighted the importance of institutions and the political environment on how economies develop and benefit from innovation. Regional Innovation Systems were more prominently used by economic geographers where the innovation process was linked to actors co-located in a geographical space (Chaminade *et al.*, 2018; Cooke, Uranga & Etxebarria, 1997). Sectoral Innovation Systems looked at the factors aligned with appropriability and technological opportunities in different industries (Malerba, 2002), primarily attributed to the innovation aspects outlined by Schumpeter as invention, recombination and imitation (Schumpeter, 1934). The aim was to focus on how sectoral attributes affect innovations without linkages to the regional and geographic context. Technological Innovation Systems on the other hand were aligned with how organisations change institutionally over time as new technological systems evolve, develop and become settled (Carlsson & Stankiewicz, 1991; Hekkert *et al.*, 2007a; Markard, Hekkert & Jacobsson, 2015). Carlsson and Stankiewicz (1991) defined TIS as systems where knowledge and competence flow under a set of institutional infrastructures around the generation, diffusion and utilisation of technology. This was based on the premise that not only firms or innovations can explain economic change (Carlsson & Stankiewicz, 1991). The different innovation systems can be sub-systems of each other. For example, a Technological Innovation System can align to national and regional dimensions of the innovation systems and may be a sub-system of several sectoral systems (Bergek, Jacobsson, Carlsson, *et al.*, 2008). There are more recent concepts that further categorise innovation systems. There is the concept of Global Innovation Systems which provides a multi-scalar conceptualisation of innovation systems. It merges the technological, national, regional and sectoral innovation systems, building on the innovation mode and valuation types of different industries (Binz & Truffer, 2017).

There are also Innovation systems that are associated with marginalised communities called Inclusive Innovation systems (Altenburg, Lundvall, Joseph, *et al.*, 2009). This categorisation came from acknowledgement that the innovation systems in developing countries are different from those in developed countries in various ways. When it comes to inclusive innovation it is important to make sure the intention, consumption, impact and (post) structure of the innovation is aligned with the marginalised and previously disadvantaged i.e. the base of the pyramid (Heeks, Foster & Nugroho, 2014). These aspects include less focus on just technological innovation non-traditional actors in the innovation process and also on processes such as business models and alternative distribution channels (van der Merwe & Grobbelaar, 2018). Of note is how the systems are built on less institutionalised frameworks, inconsistent indicators and cater for different needs. van der Merwe and Grobbelaar (2018) introduced the concept of Innovation for Inclusive Development Systems (I4IDS) in a bid to propose frameworks that can be utilised as a basis for creating indicators and analysing inclusive innovation systems. They used the technological innovation systems approach to explore the Innovation for Inclusive Development concept that was proposed by Heeks, Foster & Nugroho (2014). The work resulted in a systemic policy intervention framework and roadmap that can be utilised as a guide for developing more inclusive innovation systems (van der Merwe *et al.*, 2020; van der Merwe & Grobbelaar, 2018).

Though other studies have aimed to differentiate innovation systems and ecosystem (Smorodinskaya *et al.*, 2017), this study with Ritala & Gustafsson (2018) that innovation ecosystems can learn from other mature fields like innovation systems. The next section describes what aspects were identified from innovation systems research that can assist in understanding innovation ecosystems.

3.2.2 Innovation Systems Processes to understand Innovation Ecosystem

3.2.2.1 Knowledge in the Innovation Process

In innovation systems research a direct relationship between knowledge, learning and innovation was made by Lundvall and Johnson with what they termed a ‘learning economy’ (Lundvall, 1996; Lundvall & Johnson, 1994). This was coined from a knowledge-based economy but on the premise that knowledge by itself is not useful unless it is utilised through the process of learning. The learning economy involves the capability to learn and expand knowledge through interactive and institutionalised processes (Johnson, 2010; Lundvall &

Johnson, 1994). The level of knowledge turnover is high with dynamic changes in the knowledge itself as learning is a dyadic process that entails the combination and recombination of knowledge which ultimately results in increased innovation output. Notably, new knowledge is also attained throughout this cyclical process as shown in Figure 3.5.

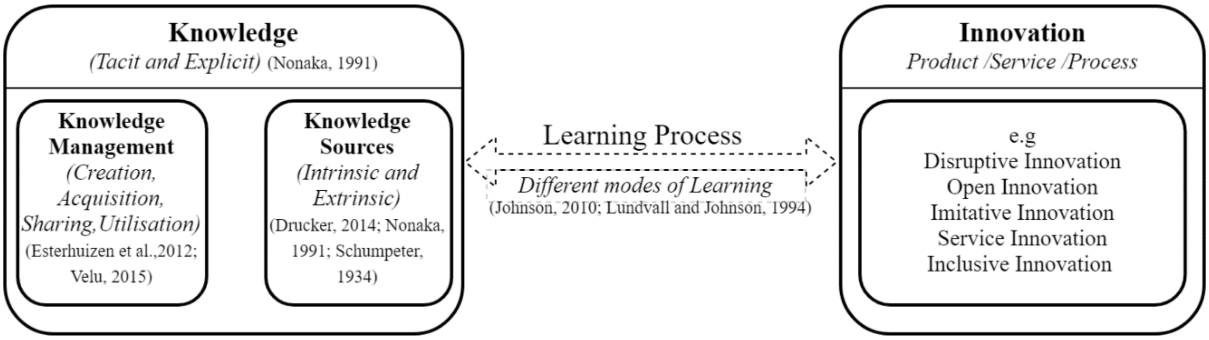

Figure 3.5: Relationship between Knowledge, Innovation and Learning Source: Author's Elaboration

So, even though this relationship had been used contextually in terms of economic implications, this is directly related to any activity that is aligned with increasing innovation either on a meso, micro or macro level. Knowledge ecosystems are more likely to include public sector participants hence making it difficult to distinguish with innovation systems especially sectoral systems.

Knowledge is a crucial economic resource and a source of lasting competitive advantage (Drucker, 1992; Lundvall & Johnson, 1994; Nonaka, 1991). It can be viewed from various perspectives aligned with a state of mind, an object, a process, access to information or a capability (Alavi & Leidner, 2001). It is deemed dynamic as it involves interaction between skills, experience, social relations, values and thought processes (Gatarik *et al.*, 2015). It is primarily categorised under explicit and tacit knowledge where explicit knowledge is formal and systematic and tacit knowledge is highly personal and cannot be formalised (Nonaka, 1991; Nonaka & Nishiguchi, 2001). Important capabilities lie around the creation, acquisition, sharing and utilisation of knowledge (Esterhuizen et al., 2012; Velu, 2015). Knowledge and the ability to quickly redistribute expertise are key factors to firm and ecosystem survival due to the high level of technological advancement, soaring innovation costs and the increasing pace of citizen demands (Iansiti and Levien, 2004; Velu, 2015). The question becomes what exactly about the knowledge is important.

Lundvall and Johnson (1994) outlined four base distinctions of the types of knowledge that are important when it comes to learning processes in innovation systems. These are to *Know-what*, *Know-why*, *Know-how* and *Know-who* in systemic innovative environments.

- *Know-what* refers to access to information or facts.
- *Know-why* deals with understanding causal relationships
- *Know-how also known as the knowledge base is about the c*apability to do things. This can be directly in a personal capacity or indirectly –by getting others to undertake an important task

- *Know-who also integrated with (know-when and know-where) pertains to* access to the knowledge and capabilities of others through specific and selective social relations of identifying what other actors know and can do.

Lundvall and Johnson (1994) highlighted that *Know-who* is the most important kind of knowledge in the learning economy. With knowledge being context specific- defined by the dimensions of space and time (Nonaka & Nishiguchi, 2001). Notably, grouping together the *Know-who*, *Know-when* and *Know-where* can lead to ignoring some important factors. By distinguishing between context, space and time as separate facets, it makes it possible look at the growth stages of the ecosystem, and this ensures that the right functionality and purpose is identified. Tackling knowledge dynamically is crucial as constantly developing and integrating it into surroundings and context allows the system to respond to disruptions (Gatarik *et al.*, 2015). This is important since knowledge which is not institutionally supported and does not fit into a cultural context tends to be forgotten, despite playing a key role in the development of new knowledge (Lundvall & Johnson, 1994). In order to fully utilise this knowledge in innovations it is important to understand what to look at, hence the function perspective of innovation systems can inform innovation ecosystems.

3.2.2.2 Learning in the Innovation Process

Learning is acknowledged as a significant driver of innovation and ubiquitous with the innovation process (Arrow, 1962; Jensen, Johnson, Lorenz, *et al.*, 2007; Johnson, 2010; Lundvall, 2010; Lundvall & Nielsen, 2007; Mukoyama, 2006). This is because through various types of learning, ideas are either sourced or refined to address various societal demands. Learning can be direct through R&D, research institutions or indirect through serendipity and unintentional output of processes with innovation and new knowledge being direct outputs. Identified types of learning are *learning-by-searching, learning-by-doing, learning-by-using* and *learning-by-interacting* (Arrow, 1962; Johnson, 2010). These learning processes recognise the complex inter-relationship between humans and non-human elements in the network (Bångens & Araujo, 2002). Jensen et al (2007) identified a need to reconcile these learning modes especially in systemic contexts and strategies aligned with innovation. They noted that at a firm level, utilisation of both modes increased innovation in organisations and the assumption is that that should hold true for ecosystems of innovation as well. These learning processes are the *Science Technology and Innovation* (STI) mode and *Doing, Using and Interacting* (DUI) mode were the two distinct innovation modes that stem from these learning processes. STI utilises codified scientific and technical knowledge whereas DUI is a more experience based mode of learning such as on-the-job training and ad hoc problem solving (Jensen *et al.*, 2007). A summary of these learning modes is outlined in Table 3.2 below.

Table 3.2: Integration of Learning and Knowledge. Source: Author's Integration of (Jensen *et al.*, 2007; Lundvall & Johnson, 1994)

Innovation Strategy	Type of Learning Process	Description	References
STI *(Know-why & Know-what)*	Learning by *searching*	• intentional systemic learning • acquired from education, training (apprenticeships), R&D, market research)-publications, reports and articles	(Arrow, 1962; Johnson, 2010)
DUI *(Know-how & Know –who)*	Learning by *doing/repetition/producing*	• learning by-product of routines and repetitious tasks and problem solving • lessons through experience in production, takes place through activity	(Nonaka & Nishiguchi, 2001)
	Learning by *using*	• lessons acquired from the users of products and services	Rosenberg (1982) referred to in (Mukoyama, 2006) (Lundvall & Nielsen, 2007)
	Learning by *interacting*	• learning that occurs from joint problem solving between actors	(Lundvall, 2016)

STI is more aligned with *Know-why & Know-what* and DUI is more aligned with *Know-how & Know-who* (Jensen *et al.*, 2007). STI innovations come from knowledge gained from understanding how a process is conducted from a factual base hence the relationship with learning through searching. Explaining causal relationships stems from an experiential form of learning in order to understand how something happens and what exactly causes such. However, in a systemic context to have a clear distinction between the paradigms is not advisable as knowing and understanding why something is occurring or happening may or may not have a scientific explanation. Hence, contextually, learning in systemic innovation is done from looking at *what is* and *what should be* (Lundvall & Johnson, 1994). But additionally in order to make it holistic *what was* is equally important in order to not repeat any former mistakes (dePaula & Fischer, 2005). Nevertheless, on an innovation systems and ecosystems level looking back historically seems to be lacking.

Technological advancement in handling and storing information has caused an upsurge in the rich information and data flows acquired from the learning processes. This presents ecosystem actors and intermediaries with the extensive problem of finding ways of knowing how, where and when to dip into these flows (Gatarik *et al.*, 2015; Lundvall & Johnson, 1994; Velu, 2015). Thus, timing of *Know-when* and *Know-where* plays a crucial part in the innovation process. The capability to learn and apply learning becomes foundational to the viability of the innovation ecosystem where the innovation intermediary or administrator has to establish rules and routines that stimulate interactive learning. Additionally, to have effectual learning in place a prepared mind and prior skills and competence are important especially in highly technical environments (Jensen *et al.*, 2007).

3.2.2.3 Relevance of Innovation Systems Functions to the Study

The innovation systems construct has also undergone critique especially around how systems are analysed. The construct has been previously deemed static due to reliance on economic static indicators for measurement such as expenditures in research and development, costs of higher education, number of scientists employed and patents (Hekkert *et al.*, 2007a). This seemed to exclude various levels of complexity that are in innovation systems especially from a spatial and socio-technical perspective. The theoretical, historical and empirical analysis of innovation systems was noted to be more from a 'components based' approach that looked at the identification of individual elements that defined the growth of the innovation systems aligned with producer-user interaction (Chaminade *et al.*, 2018). These are studying aspects of knowledge creation, distribution and power dynamics (Bergek, Jacobsson, Carlsson, *et al.*, 2008); assessing the impact of organisational activities on the system (Jensen *et al.*, 2007; Lundvall & Johnson, 1994); identifying policy incentives that stimulate public intervention in taking part in the system (Lundvall *et al.*, 2009) and innovation process activities that are important for turning an idea into an innovation (Bergek, Hekkert & Jacobsson, 2008; Hekkert *et al.*, 2007a). To overcome this there resulted the 'functions-based' approach that looked at the main activities in the system (functions) aligned with supporting the innovation process (Bergek, Jacobsson, Carlsson, *et al.*, 2008; Binz & Truffer, 2017; Hekkert *et al.*, 2007a; Markard *et al.*, 2015).

The functions-based approach (mainly from the TIS perspective) introduced standardisation around the innovation systems concept (Bergek, Jacobsson, Carlsson, *et al.*, 2008). This is important as it enables learning from innovation systems and gives room for other constructs like innovation ecosystems to be compared with innovation systems and provide clarity. The most prominently used functions are aligned with systematically mapping activities in the innovation process that result in technological change (Alkemade, Kleinschmidt & Hekkert, 2007). This has given various researchers to group functions from these different perspectives outlined in Table 3.3 below:

Table 3.3: Innovation Systems function Research edited from (Chaminade et al., 2018)

Author	Purpose	Set of Functions
(Galli and Teubal, 1997)	• Distinguish between hard and soft functions • Offer a schematic description of paradigmatic and structural changes occurring in National Systems of Innovation (NSIs);	*Hard functions* • R&D activities • Scientific and technical services to 3rd parties *Soft functions* • Diffusion of information, knowledge and technology • Policy making • Design and implementation of institutions around patents, laws standards, • Diffusion of scientific culture • Professional coordination

Author	Purpose	Set of Functions
(Johnson, 2001) (cf. (Hekkert et al., 2007)	• To merge existing understanding of innovation function approaches for the different functions • To elaborate on the usefulness of functions in innovation system studies.	• Create new knowledge • Supply incentives for companies • Supply resources -capital and competence • Guide direction of search (influence the direction in which actors deploy resources • Recognise potential for growth (identifying technological possibilities of economic viability • Facilitate exchange of information and knowledge • Stimulate/create markets • Reduce social uncertainty • Counteract the resistance to change that may arise
(Liu and White, 2001)	• Proposes a generic framework for analysing innovation systems • Address the lack of system-level explanatory factors	• Research (basic development, engineering) • Implementation (manufacturing) • End-use (customers or process output • Linkage (bringing together complementary knowledge) • education

(Edquist, 2001)	• Evaluate the state of the art with regard to the Systems of Innovation approach and development
	  ○ Identify the main theoretical and empirical advances
	  ○ Identify the most challenging problems associated with the approach
		• Provision of R&D
		• Competence building
		• Formation of new product markets
		• Articulation of quality requirements from demand side
		• Creating and changing organisations need for development of new innovations
		• Networking through markets
		• Creating and changing institutions
		• Incubating activities
		• Financing of innovation processes

(Hekkert *et al.*, 2007a)	• Propose a framework for well performing innovation systems • Propose a method for systematically mapping processes taking place in innovation systems and resulting in technological change.	• Entrepreneurial activities • Knowledge development • Knowledge diffusion • Guidance of search • Resource mobilisation • Creation of legitimacy
(Bergek, Hekkert, et al., 2008; Bergek, Jacobsson, et al., 2008)	• Step-by-step approach to analysing innovation systems, describing and assessing performance and identifying key policy issues • Captures the structural characteristics and dynamics of an innovation system, but also the dynamics of a number of key processes, labelled functions.	• Entrepreneurial activities • Knowledge development and diffusion • Influence on the direction of search • Entrepreneurial experimentation • Market formation • Legitimation • Resource mobilisation • Development of positive externalities

One of the main disadvantages of this approach is the assumption that the lists of functions are equally applicable to all systems without any regard to time and space (Bergek, Jacobsson, Carlsson, *et al.*, 2008; Chaminade *et al.*, 2018). They can either be general and basic or designed for in-country contexts which can skew comparisons and learning from other systems. Chaminade et al (2018) noted that the function lists tend to omit the importance between the creation and use of knowledge. Most of the listed functions separate the creation of knowledge from the diffusion of knowledge which in practice are interdependent activities. Furthermore, methodologically issues on using the functions-based analytical framework were around determining the level of analysis that is being undertaken in terms of the knowledge field and value that is being created in the system as well as outlining system boundaries (Carlsson, Jacobsson, Holmén, *et al.*, 2002). Though there might still be discrepancies in how the function-based approach is applied, this study aligned with the importance of standardisation in the approach when it comes to studying innovation ecosystems (Jacobides *et al.*, 2018). With the functions being used as a starting point of analysis this assists in concreting the innovation ecosystems construct in that there are already identified aspects of the activities that are associated with an innovation system.

The functions that were used as a referral point in this study were the ones collated by Bergek, Hekkert & Jacobsson (2008) and Hekkert et al (2007a) which looked at entrepreneurial experimentation, knowledge development and diffusion, guidance (influence in the direction of search, market formation, resource mobilisation and creation of legitimation in the system. However, the innovation ecosystem construct was not the only one used to inform the types of activities that are important and aligned with the ecosystem. As most innovation ecosystems are now looking to be inclusive, the usage of innovation systems function in Innovation for Inclusive Development Systems (I4IDS) was considered important. Knowledge development and diffusion is at the heart of TIS and I4IDS where the different processes are outlined for the new systems to emerge, grow and gain momentum. One important study related with growth of innovation systems has shown how the lifecycle stage (*formation, upscaling and growth*) of the TIS affected the activities undertaken in the innovation system (Bento & Fontes, 2015; Hekkert *et al.*, 2007a). Where the *Formation Phase* deals with functions such as knowledge creation, creation of legitimation and its impact on other functions and *Upscaling and Growth Phases* address legitimation and institutional arrangements.

The relevance of IS functions to healthcare context was also something that was important to consider in this study. Van der Merwe & Grobbelaar (2016) and Van der Merwe et al.,(2020) explored the applicability of Hekkert and Bergek's TIS functions on a mHealth case study of a South African maternal health application called MomConnect. They applied the seven functions to map activities around the application aligned with inclusive innovation and how business models can be mapped around the application (van der Merwe *et al.*, 2020). This study went on to outline systemic instruments that can be utilised to understand business models in inclusive innovation (healthcare) initiatives. An explanation of these basic functions is shown in Table 3.4 below.

Table 3.4: Definitions and Activities Identified from Innovation Systems and Inclusive Innovation Systems collated from (Bergek, Jacobsson, Carlsson, *et al.*, 2008; Bergek, Jacobsson & Sandén, 2008; Hekkert, Suurs, Negro, *et al.*, 2007b; van der Merwe *et al.*, 2020).

Function	Function description	Innovation System Functions Typical Activities	Innovation for Inclusive Development System Activities
Entrepreneurial experimentation (*and activities)* **[F1]**	Exploration and experimentation with new technology[8]	• New entrants and start-ups • Portfolio diversification activities-new applications • Technology experimentation/manufacturing, installing and constructing (Experiments) • Projects with a commercial aim	• Inclusion of marginalised community within business models • Opportunities for marginalised partake in entire innovation development • Loans and funding to marginalised groups • Projects with clear goals of sustainable inclusive entrepreneurship • Development of remote community owned projects
Knowledge development- *(formal learning)* **[F2]**	Mechanisms of technological learning associated with *'learning by searching'* and '*learning by doing*'	• Studies-Academic research • Laboratory trials • Undertaking pilot studies • Prototype development • Investment in R&D projects • Demonstration projects - Developing new prototypes • Patents produced • Producing journal publications and reports • Surveys, Monitoring studies, feasibility studies - Conducting impact assessments • Provision of physical and legal infrastructure • Adapting or modifying models	• Market pull strategies take requirements of marginalised into account • Market push strategies are focused on sectors of most value to marginalised • Focussing on knowledge, development and collaboration • Formal knowledge focus on marginalised livelihoods • Considerations of literacy, capabilities and capacity of marginalised groups in design and development of innovations • Collaboration between formal and informal research organisations • Using marginalised actors as knowledge providers • Forms of training and development provided to marginalised groups
Knowledge diffusion **[F3]**	The presence of knowledge sharing channels or networks among key actors, encompassing *'learning by*	• Conferences, workshops, seminars meetings • Networks, Alliances between actors • Joint ventures • Setting up of platforms/branch organisations • Training of community members/ technicians or constructors	• Emphasis on ability of diffusion of important information to enhance I4ID • Creation of platforms for informal and formal sector actors to engage • Development of knowledge channels between informal and formal sector actors

[8] *Technology* encompasses artefacts and knowledge, where artefacts are in the form of hardware (i.e. machinery, products and design tools) or software (i.e. procedures, processes and digital protocols). Knowledge is the tangible and intangible competence amongst actors (Bergek, Jacobsson & Sandén, 2008).

Function	Function description	Innovation System Functions Typical Activities	Innovation for Inclusive Development System Activities
	interacting' and *'learning by using'*	• Project related campaigns/ Conducting awareness campaigns • Publication of results from studies	• Knowledge of marginalised group is considered as a core influence for decisions by top decision makers • Using marginalised actors as distributors of knowledge within the marginalised community • Translating important knowledge into local language of marginalised group • Removing barriers that hinder communication between marginalised community actors and other actors in the system
Guidance of search *(influence in the direction)* **[F4]**	Guidance to actors to mobilise resources	• Expressing interest, vision and expectations • Articulation of direction and alignment of expectations of relevant actors, • Establish long-term targets of governments and industries • Setting policy targets, policy documents • Setting standards and research outcomes • Spurring interest in the community -e.g. providing awards	• Government policies oriented toward inclusive development • Setting clear and achievable targets • Enhancing belief in the potential of a project • Policies formed to enhance empowerment and capabilities of marginalised groups
Market formation *(and identification)* **[F5]**	Create protected spaces to facilitate market development for new technologies	• Provision of subsidies (share cost of investment) • Regulatory reform supporting niche markets • Specific tax regimes, incentives and exemptions • Standardisation: new standards that improve the environment • Public procurement	• A shift in the central foci of the project: from product-centric to business model innovation of which the product simply form part • Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation
Resource mobilisation **[F6]**	Mobilisation of resources geared at promoting a new technology development, diffusion and use.	• *Human capital*: education, specialized training programs • *Financial capital*: venture capital, public seed money, financial incentives /loans private investments, financial incentives, grants • *Physical resources*: natural resources and infrastructure developments • Mobilising cooperation with the private sector	• Incentives for successful scaling of programme or innovation encouraging local entrepreneurs to actively take part • Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID • Alignment of resources to needs of the system • Acquiring technological infrastructure

Function	Function description	Innovation System Functions Typical Activities	Innovation for Inclusive Development System Activities
Creation of legitimacy **[F7]**	The advocacy efforts of actors around the socio-political process of counteracting resistance to change	• Conducting advocacy activities e.g for resources) • Give advice • Promote interest and advocacy coalitions • Promote networks around technology • Legitimising technology • Undertake exhibitions / workshops • Promote technology platforms	• Build legitimacy around the effect of interventions within marginalised groups • Engagement with marginalised groups and forming trustworthy relationships • Provide evidence for benefit of interventions for both formal actors and marginalised groups

A way of categorising all these dynamics that occur in healthcare systems from an innovation systems perspective was outlined by Hanlin & Andersen (2019) who merged both the components-based and functions-based approaches and summarised them into what they called the 4F framework shown in Figure 3.6. The framework outlines the health system in four distinct categories. The *field* (markets and institutions in which the innovative activity takes place), *function* (the ultimate goal of the contextual innovation), *form* (system actors identification, interaction and collaboration dynamics) and *flows* (the origins, creation and the ways in which the system is conceptualised) (Hanlin & Andersen, 2019). The 4F framework gives a source of structure for the innovation ecosystem perspective utilised in this study.

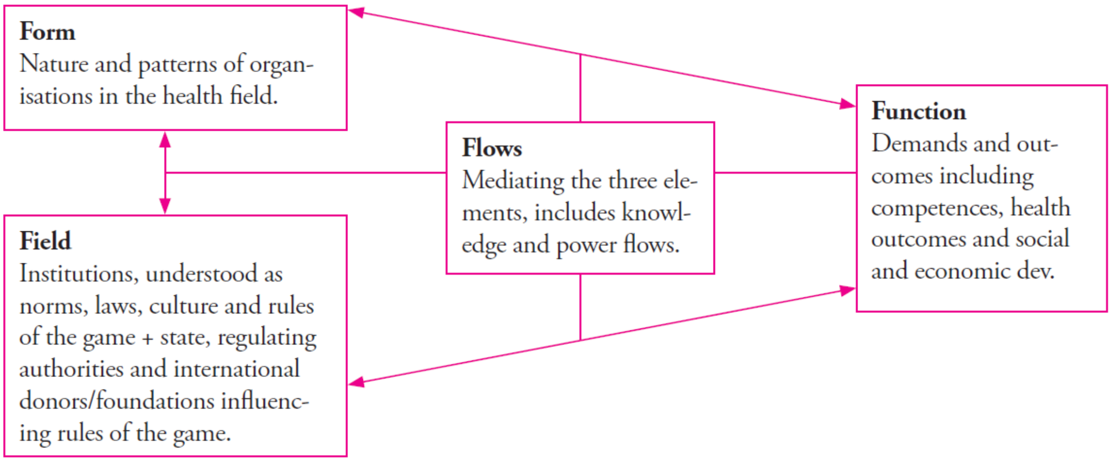

Figure 3.6: The 4Fs and their Interlinkages (Hanlin & Andersen, 2019)

When now looking at an innovation ecosystem perspective, the author contends that these facets still stand but propose to delinearise the relationships between the linkages giving a nested concentric dynamic outlined in Figure 3.7.

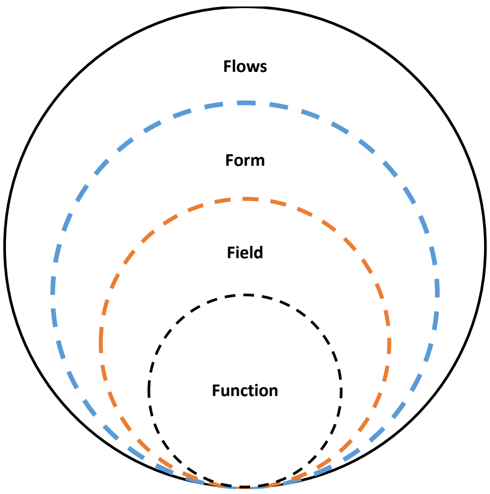

Figure 3.7: 4Fs aligned with Innovation Ecosystem Evolution

Linking the 4Fs shown in Figure 3.7 back to the definition suggested by Adner (2017) of aligning '*ecosystem as structure*', the function of the ecosystem would be the strategic alignment and overall goal of the ecosystem which needs to be defined first. This dictates the field, forms and flows of tangible and intangible knowledge and resources in the ecosystem, where in an innovation ecosystem the heart is the function of what value is purported. This dictates the constituency of the actors and knowledge flows that occur amongst the actors. How the 4F framework and innovation systems functions are utilised as part of the framework is shown in Figure 3.8 and will be explained in Chapter 6.

In an innovation ecosystem, an innovation intermediary has various responsibilities that are prescribed as contributing to effectual learning. Weng and Lai defined innovation intermediaries as "*organizations or firms within the network that work together to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of ideas, knowledge or technologies*" (Weng & Lai, 2014: 4). These intermediaries ideally should supply the means to learn, offer incentives to learn, open up the capability to learn, open access to relevant knowledge and offer the opportunity of learning to forget (Lundvall & Johnson, 1994).

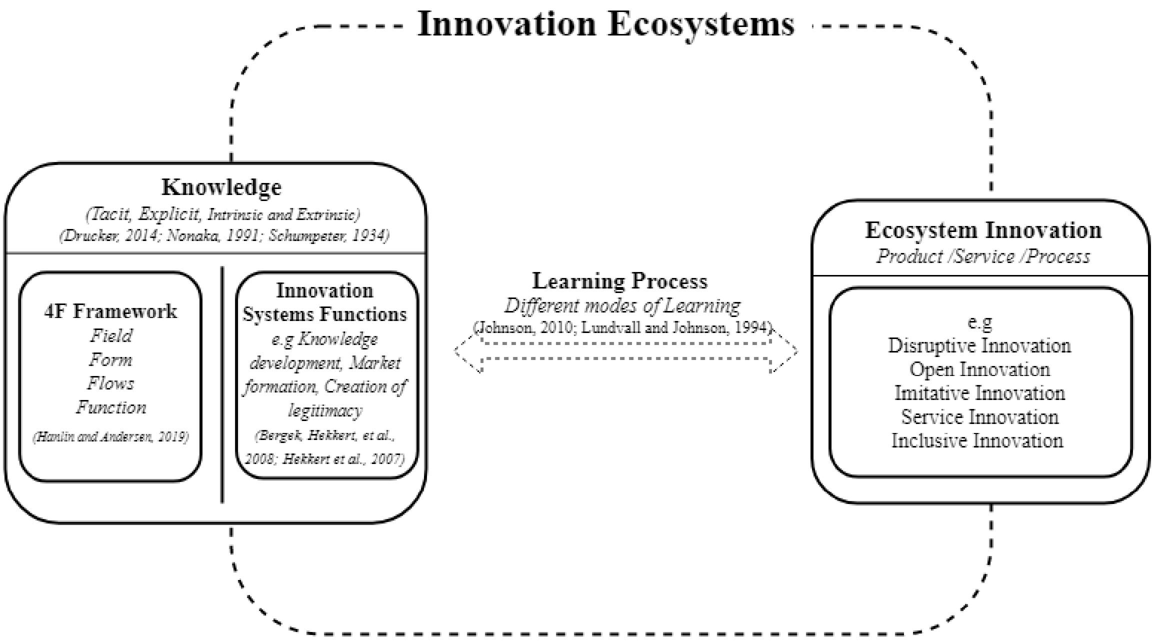

Figure 3.8: Innovation Systems functions informing Innovation Ecosystems

Additionally, throughout this learning process the knowledge that is an output of all the recurring innovation processes should be efficiently managed. Knowledge management covers any systematic and intentional '*process of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance leaning and performance in organizations'* (Swan, Scarbrough & Preston, 1999: 669). This merges well with the defined roles of an innovation intermediary that are aligned with facilitating, configuring and brokering innovation between two or more parties (Howells, 2006). Hence, in order for an intermediary to do its job effectively in the innovation ecosystem, there has been a direct alignment with the acquisition, sharing and utilisation of knowledge (Velu, 2015). A more in-depth review of innovation intermediaries is offered in the next chapter.

Learning amongst actors involves shared meaning and communication practices that ensure that no information is lost through the various communication portals available to ecosystem participants.

Velu (2015) highlights that an intermediary or lead firm requires knowledge management capabilities that enable it encourage the innovation ecosystem to be able to sense market shifts, create knowledge and respond to fast-changing environments. In resource-constrained environments, this aids as a bonus because there can be a readily available knowledge base to build projects. Especially, in service delivery contexts such as healthcare it can cut the project start up times drastically through utilisation of readily available resources instead of rescoping. This is where innovation intermediation in innovation ecosystems becomes relevant through the intermediary morphing from just being just a facilitator but a source of vision and knowledge (Ngongoni, Grobbelaar & Schutte, 2018b; Velu, 2015). Nevertheless such environments are tricky to manage as knowledge bases differ amongst ecosystem actors and with technology advancement, this results in various knowledge pockets in the ecosystem (Gatarik *et al.*, 2015; Velu, 2015).

An important aspect which is of great relevance in this study is the concept of *learning to forget*: this is the capacity to preserve and store knowledge, selecting relevant skills whilst abandoning obsolete skills and having systems in place that redistribute the knowledge and compensate any 'victims' of change (Lundvall, 1996; Lundvall & Johnson, 1994). Forgetfulness should not translate to loss of important information but rather to a repository of maybe how previous projects were undertaken. In organisations, the storage, organisation and retrieval of knowledge is important and undertaken in various ways (Alavi & Leidner, 2001). This study puts forward that the context of having sound knowledge commons that innovation actors can access and feed from not only aids the intermediary but quickens the value co-creation process of the actors. Knowledge storage (*process of forgetting*) becomes an important aspect to the evolution of the ecosystem. This ultimately leads to increased value creation and the evolution of the ecosystem. This directly corresponds to the complex adaptive nature of the ecosystem where past experience and events influence the current state (Cilliers, 1998).

3.3 Chapter Conclusion

This chapter defined innovation ecosystems and outlined the key attributes that are aligned with their evolution. This chapter also outlined the crucial role of knowledge and learning in assisting an innovation ecosystem to address its value proposition. This is to reiterate that this study aims to add aspects that look beyond just technical and descriptive aspects in innovation ecosystems to address competency building of ecosystems from strategy, culture, institutions and organisation (Oh *et al.*, 2016; Ritala & Gustafsson, 2018). The next chapter addresses how the learning process in an ecosystem can be informed further through aligning the innovation ecosystem as a Complex Adaptive System.

Chapter 4: Defining Innovation Ecosystems as Complex Adaptive Systems

"You think that because you understand "one" that you must therefore understand "two" because one and one make two. But you forget that you must also understand "and."
— Donella H. Meadows

This chapter outlines how innovation ecosystems can be denoted as Complex Adaptive Systems (CAS) and the elements that can be utilised from that viewpoint for analysis as shown in Figure 4.1.

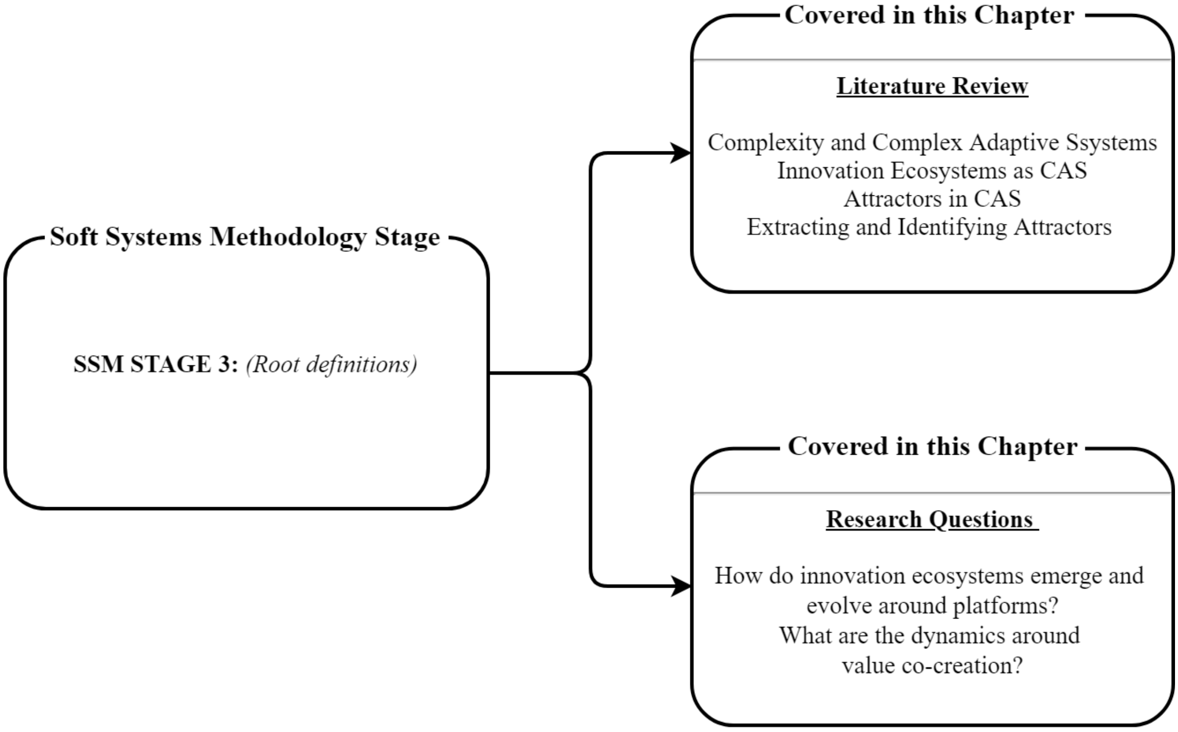

Figure 4.1: The Structure of Chapter 4 within the Context of the Soft Systems Methodology.

4.1 Complexity Science and Complex Adaptive Systems

Complexity science has been a field attributed to give rich descriptions and empirically valid depictions of innovation and how firms survive and adapt (Newth, Shepherd & Woods, 2017). It is more about describing the present and seeing what can be changed rather than predicting the future or defining the ideal state of a system (Jucevičius & Grumadaitė, 2014; Ramalingam *et al.*, 2008). Complex Adaptive Systems (CAS) is a field within complexity science which studies the adaptation dynamics of agency and how order emerges in systems rather than being designed (Braa, Sahay, Lewis, *et al.*, 2017; Kuhmonen, 2017). CAS have been noted to constitute of inter-dependent agents that are adaptable, co-evolve, self-organise, emergence, have distributed control, exhibit non-linearity and are unpredictable (Cilliers, 1998; Mitleton-Kelly, 2003; Palmberg, 2009; Plsek & Wilson, 2001). However, it is possible to find inherent order and structure in the complex systems though they are unpredictable (Palmberg, 2009; Stacey, 1995). The lens of complexity has the potential to contribute to understanding the emergence and evolution of innovation ecosystems (Newth *et al.*, 2017; Phillips & Ritala, 2019). In the same vein, this applies to the ecosystem view where numerous independent actors interact according to particular rules where they co-adapt, co-learn, and co-evolve.

Holmes et al. (2016) highlighted that many complexity aligned studies, especially in a socio-technical context, rarely discuss anything beyond the conceptual level. In the case of those studies which go beyond mere descriptions and metaphors, there tends to be knowledge produced by researchers that gets disseminated to users as directives with sequential steps that "*presuppose a high degree of rationality and linearity in the system*" (Holmes *et al.*, 2016: 2). However, determining how to act in complex system is a multifaceted matter as there is no single point of control and planned change is difficult. Observing how change occurs can help determine how best to manage such change and complexity science can actively inform and shape what is happening within organisations (Hazy, 2011). The alignment of CAS with innovations ecosystems gives premise for analysing innovation ecosystems using CAS principles and characteristics.

4.2 Innovation Ecosystems as Complex Adaptive Systems

A CAS is a collection of individual agents that have the freedom to act in ways that are not always predictable but whose actions are interconnected and affect the context for other agents (Plsek & Greenhalgh, 2001). Ideally, the agents self-organise without any form of centralized control (Eidelson, 1997). CAS interact, adapt and learn (Boal & Schultz, 2007). The characteristics of a CAS are shown in Figure 4.2 below.

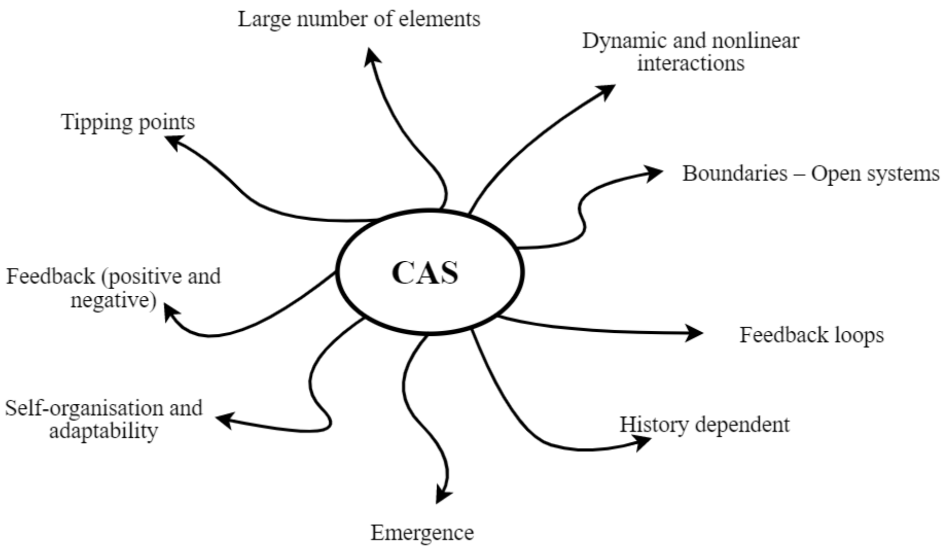

Figure 4.2: Characteristics of CAS from (Cilliers, 1998; Meadows, 2008; Mitleton-Kelly, 2003)

The proposition to align ecosystems research with complexity theory and CAS is nothing new. The main way that CAS theory was utilised is through alignment in this study. Roundy et al. (2018) outlined how properties of CAS, namely self-organisation, nonlinearity, complexity, adaptability, openness and sensitivity to initial conditions are prevalent in entrepreneurial ecosystems. Jucevičius and Grumadaitė (2014) modelled an innovation ecosystem by integrating both top-down and bottom-up development approaches as a smart system based on characteristics of CAS. Russell and Smorodinskaya (2018) described the generic properties of innovation ecosystems in terms of CAS with special attention to the complexity of innovation clusters. Gear et al (2018) reconceptualised a healthcare related research problem as a CAS. This means that they looked at the theoretical aspects that are aligned with CAS and explored how the agents (funders, policy makers, doctors, social workers) defined and viewed intimate partner violence as a health issue. They explored how this discourse had influenced the interactions and communication between the agents and contribute to (or blocks) the emergence of discourse(s) which influence sustainable responses to such violence. They utilised concurrent document analysis and participant interviews with the aim to produce rich and diverse data that reflect the state of the local and global intervention efforts on health and violence prevention across a range of participants working in diverse communities.

On the other hand, Phillips and Ritala (2019) proposed a CAS lens as a framework to address the conceptual, structural and temporal aspects in ecosystems studies. They gave separate methodological frameworks for perspective and boundary mapping, hierarchy and relationship mapping, and dynamics and co-evolution mapping that can be applied both quantitatively and a qualitatively. The illustrative example comprised of the merging of six ecosystems that were analysed at the early-life cycle stage. This led to suggestions of key methodological issues, and the adopted research approaches were of each ecosystem.

Innovation ecosystems can be noted as CAS through a variety of ways highlighted by various researches:

i. Large number of elements, dynamic and nonlinear interactions: CAS consist of a substantial number of heterogenous elements that interact in a dynamic way that evolves with time. Interactions can both be physical or entail the transference of information regardless of context (Cilliers, 1998). Innovation ecosystems usually entail many ecosystem actors that interact in a dynamic way where a lot of value is in the interrelationships between the actors (Autio & Thomas, 2014; Gawer & Cusumano, 2014; Jucevičius & Grumadaitė, 2014). These interactions have no proportionality as a small shift in the ecosystem can either propel the whole ecosystem to new innovations, cause some actor to collaborate or compete with other actors or cause the innovation ecosystem to die (Almpanopoulou, Ritala & Blomqvist, 2019; Moore, 1993).

ii. Influential behavior and tipping points: An element in a CAS influences and is influenced by others, hence the interactions are fairly rich (Meadows, 2008) and it is the same in innovation ecosystems. The behavior of the system is not determined by any exact number of interactions. Nevertheless, interactions are non-linear, thus small causes can have large results and vice versa. Malcolm Gladwell suggested that social tipping points are brought about by mavens (information gatherers), sales people (convincing others of their point of view) and networkers (who connect a wide range of people) (Gladwell, 2002). Though Gladwell described these in terms of personalities, this can be aligned to ecosystems where ecosystem actors with the same characteristics play a crucial role in the ecosystem and how adaptive the ecosystem is. In innovation ecosystems, interactions are determined by the value proposition of the ecosystem, they are not determined by any exact number of interactions; the onus is on how knowledge is created, disseminated, utilized and stored that also plays an important role with the evolution of the ecosystem (Scaringella & Radziwon, 2017; Velu, 2015).

iii. An open system with distinct boundaries: Defining boundaries of a complex system is often difficult as complex systems are deemed open systems as they interact with the environment. So, for a CAS the scope of the system is usually determined by the purpose and description of the system. This is referred to as framing and often influenced by the position of the observer (Cilliers, 1998; Mitleton-Kelly, 2003). Innovation ecosystems fall under such a description as the actors are defined according to scope, affiliation or organisational boundaries. The scope (framing) is usually the purpose of the innovation ecosystem (Jackson, 2011; Jacobides *et al.*, 2018). Furthermore, the interaction level of the ecosystem is defined by the operational environment such as industry alignments or country economic dynamics.

iv. Historical reference and pattern formation: CAS have a history which explains their present behavior (Roundy *et al.*, 2018). They are capable of learning of learning based on information and experience (Kuhmonen, 2017). In innovation ecosystems this is a fundamental aspect where technological, spatial and temporal aspects affect the resultant interactions and collective behavior of the innovation ecosystem. This is one of the pivotal aspects in theory building and modelling seeing as how historical knowledge and information is managed and disseminated determines some actions undertaken by ecosystem actors (Velu, 2015). Notably, any analysis of a complex system that ignores the dimension of time is incomplete (Cilliers, 1998). The history and past actions of actors in an ecosystem can assist management to proactively be aware of the dynamics occurring in the ecosystem.

v. Self-organisation and adaptability: CAS are deemed unpredictable due to self-organisation and (Cilliers, 1998; Mitleton-Kelly, 2003). The ability for an organisational and social structure to behave as a CAS has been associated with the ability to adapt successfully to rapidly changing environments with no need for centralised control (Eidelson, 1997). However, when looking at systems, there is a form of direction or management in one way or the other. It might be in the confines of the CAS environment, or external conditions that can be imposed to change the dynamics of the system (Russell & Smorodinskaya, 2018). Nevertheless, Jucevičius and Grumadaitė (2014) identified societal system holders aligned with ecosystems that are responsible for activities such as visioning, rule setting, building and maintaining feedback and building attractors. This is also an aspect that this dissertation argues for - the necessity of some form of innovation intermediary that assists the evolution and emergence of the ecosystem through various proactive and reactive activities.

vi. Feedback (positive and negative) loops: Innovation ecosystems have feedback loops that arise from the interactions between different actors and resource providers like funders or human capital. Feedback is also in the form of results aligning strategic initiatives and policies with what the ecosystem has produced (Eidelson, 1997; Roundy *et al.*, 2018; Valkokari *et al.*, 2017). Another form of feedback can also be between the ecosystems and external elements that define boundaries (Roundy et al., 2018). There is also feedback between the ecosystem and the elements outside it, which helps define its boundaries. Roundy et al., (2018) suggested that the quantity and quality of these feedback linkages within an ecosystem probably determine its overall effectiveness due to the mutual interdependence of ecosystem actors behavior to other actors.

*vii. Attractors: C*omplex systems gravitate between varying states of chaos and stability (Kuhmonen, 2017). In order for the system to move from one state to the next, an event has to occur in the system and that is known as a tipping point or attractor. These various attractors configure the evolution of CAS (Kuhmonen, 2017). Attractors have varying definitions; Kuhmonen (2017) aligned with the definition that identifies an attractor as something towards which the systems evolves over time. Likewise, in an innovation ecosystem, there are central activities deemed attractors that influence how the ecosystem evolves or responds to externalities. One suggested way of identifying is the mapping of causal processes and agent relationships to gain insight into the conditions that trigger causal mechanisms to produce outcomes (Cilliers, 2001). This aligns with the Event Structure Analysis mentioned in Chapter 2.

This is one of the aspects this study aligns with; how the ongoing interactions in an innovation ecosystem and the context determine the outputs and value that is created in the system. Such interactions attribute to states of chaos where stability in dynamic systems has been attributed to the notion of attractors. These attractors are the cornerstones where change occurs in the system (Kauffman, 1993). In this dissertation the characteristics aligned with attractors, feedback loops and the history of the ecosystem are the main CAS characteristics that are included in the framework. Whilst the aspects of historical events and feedback loops are clear, the application of attractors to innovation ecosystems needs more clarification.

4.3 Attractors and Leverage points in CAS

This section outlines how change is identified in a CAS. It will primarily concentrate on the notion of attractors and leverage points as key aspects that inform the study.

4.3.1 Understanding Attractors

In complexity science, behaviour is typically defined to a limited state space. According to complexity theory, the boundaries or dimensions of any system can be mapped using a phase space. Phase space is deemed a useful way to describe complex systems as it attempts to shed light on the underlying patterns that are apparent when looking across all the key dimensions in the system The phase space can be developed by identifying all the dimensions that are relevant to understanding the system, then determining the possible values that these dimensions can take over time (Romenska, 2006). The phase space can be represented in a graphical or tabular format which are popular forms or representation in natural sciences and social scientific thinking respectively (Ramalingam *et al.*, 2008).

It is a set of all the possible states/phases that a system can occupy. An example of a phase space in a higher education system is the number of institutions, private or state institutions, students, staff, etc. (Romenska, 2006). Each dimension can have a certain, limited set of values – for example, if a university system can educate maximum number of students, the dimension 'number of students' can have values ranging from 0 to x, giving rise to a range of different states (Romenska, 2006). Ordinarily the figures may vary every year and not be expected to dramatically change the character of the university system. However, some behavioural traits might have to change such as the shift that occurred with the onset of COVID-19 as institutions rushed to try to salvage the academic year. Using this approach can reveal that different dimensions are alternatively constant, stable, evolving or unpredictable.

Another example of a phase space when aligned with whether the leadership strategy of a system that is focused on people/actors and goal behaviour or strategies can be represented as shown in Figure 4.3.

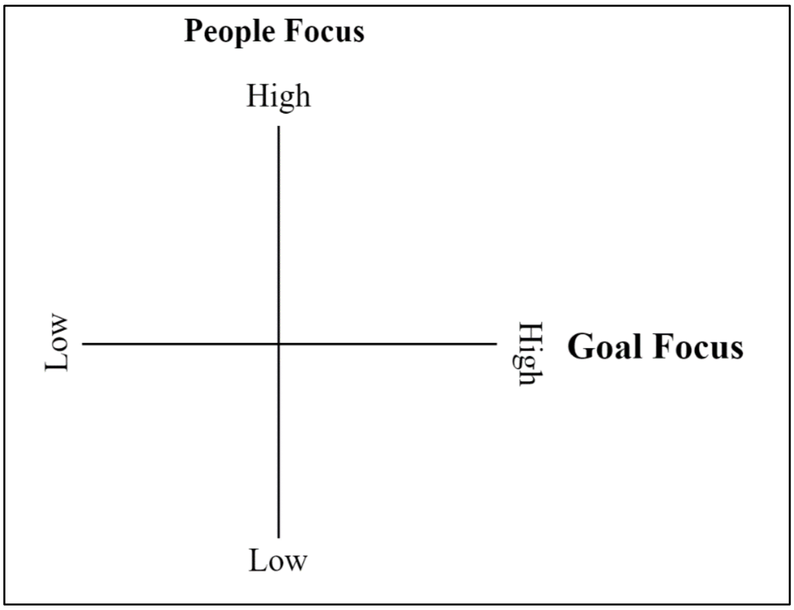

Figure 4.3: Complex Adaptive Leadership Model – basis Source: (Obolensky, 2016)

Certain regions of this state space are occupied more than others due to recurring interactions amongst the agents over time – these are the points or regions known as attractors (Ramalingam *et al.*, 2008). An attractor is a "*set of points or states in the state space to which trajectories within some volume of state space converge asymptotically over time*" (Kauffman, 1993: 175). Attractors are also noted "*as a subset of possible configurations that are possible within a particular dynamic system"* (Newth *et al.*, 2017: 79). The CAS naturally gravitates towards and remains cycling through these attractors unless perturbed and may correspond to a desired or undesired end-state or goal (Cilliers, 1998; Nowak, Vallacher & Zochowski, 2005). They have the ability to define the behaviour agents in a CAS and push a system in a different direction that can include death and hence can potentially constrain the choices and actions of the system actors (McDonald, 2009; Nowak *et al.*, 2005). Attractors capture the interplay between structure and dynamics in a complex system and are the stable conditions that govern socio-technical systems (Hazy, 2011; Nowak *et al.*, 2005).

The primary types of attractors identified in complexity science are fixed-point, cyclic (periodic) and strange attractors. Fixed-point attractors keep a system at a constant stable point. Thus, a system governed by fixed-point attractor dynamics "*will consistently evolve to a particular state, whether or not this state is hedonically pleasant, and will return to this state even when perturbed by outside influences that might promote a more pleasant state*" (Nowak *et al.*, 2005: 355).

Cyclic attractors keep a system in a cyclic state and move in a linear or orbital pattern that moves toward and away from a set point in a regular fashion. Even though the trajectory may change from iteration to iteration, it is also predictable (Hazy, 2011). An example of such is the motion of a pendulum. Periodic attractors have also been called coaching, directive, development or reminder attractors (Obolensky, 2016).

Strange attractors keep a system in a turbulent or chaotic state due to the high information input and feedback mechanisms are the characteristics of strange attractors that lead to adaptive systems (Gilstrap, 2005; Nowak *et al.*, 2005). An understanding of these strange attractors was suggested to lead to an understanding of underlying dynamics in a system which can ultimately lead to interventions to ensure that agents function more effectively within a turbulent environment

(McDonald, 2009; Newth *et al.*, 2017). This is essential if innovation processes are to be thoroughly understood as 'recombinations' of knowledge, new and old (Schumpeter, 1934). A strange attractor is where the behaviour in a system never repeats itself, and an example is how the staff complement and student intakes at a university always fluctuate annually (Romenska, 2006).

Other variations of strange attractors have been social attractors, structural attractors (Allen, 2001; Hazy, 2011, 2012; Newth *et al.*, 2017) and 'attractors for change' (Braa & Sahay, 2012; Braa *et al.*, 2017; Plsek & Wilson, 2001). A social attractor is a subset of states that a social group or an individual naturally gravitates towards[9]. Social attractors were noted to serve as reference points in social processes associated with the power dynamics of construction, mobilisation, establishment, contestation, and resistance (Hatt, 2013). Examples of social attractors are poverty, education, public health, or clean water (Haynes, 2008). They are also conceptualised as operating in complex, self-organising, nonlinear arrangements as are ecosystems in resilience thinking. Diagrammatic depictions of the attractors are shown in Figure 4.4.

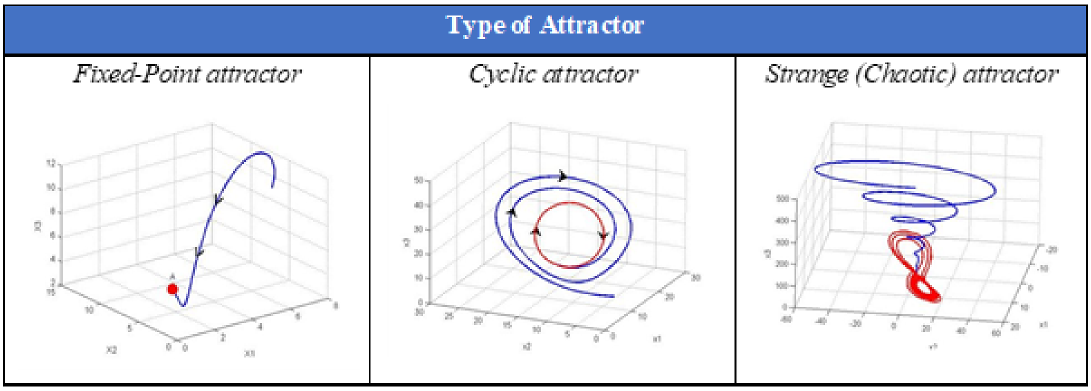

Figure 4.4: Types of attractors[10]

Structural attractors exhibit "*the emergence of a set of interacting factors that have mutually supportive complementary attributes*" (Allen, 2001: 36). Structural attractors have three dynamic contexts which are convergent, divergent, or unifying (Newth *et al.*, 2017). These contexts arise due to the nature of the system and the various interdependent actors operating within the system and the interaction of the system with its wider community. Rather, often structural attractors develop by chance and through self-reinforcing behaviour of the system itself (Hazy, 2011). Examples of structural attractors are transportation hubs, warehouses, business plans, business models, budgets, indigenous communities (Hazy, 2011, 2012; Lythberg, Henare & Woods, 2015; Newth *et al.*, 2017).

'*Attractors for change*' or change attractors come from the premise that simply understanding attractors is not always sufficient as systems generally require tension to change (Plsek & Wilson, 2001). Hence this term was used to highlight focal points and activities in the system that foster change. An example of a change attractor is a shared standard that creates synergy between disagreeing actors (Braa *et al.*, 2017). Plsek (2001) gave an example where a General Practitioner's practice might be noted in a healthcare system as not utilising important healthcare standards. The

[9] https://systemsinnovation.io/glossary/social-attractor/

[10] http://www.scholarpedia.org/article/Attractor_network#Cyclic_attractors

common management approach would be to enforce strategy sanctions and strict budget controls in order to force conformance. But a change attractor approach would be to ask, '*what changes and innovative practices has the practice previously adopted, or even pioneered?*' In doing so then one gets to the root cause of the problem, which might be that the new guidelines do not resonate with what is meaningful to the GP practice, it gives room to see if the guidelines should be amended to fit better with the value proposition of the GP practice and hence improve compliance. Other attractors can be habits, routines, dominant designs, preferences, ideals, innovations (Kuhmonen, 2017). An example of how attractors can push systems into different states is shown in Figure 4.5.

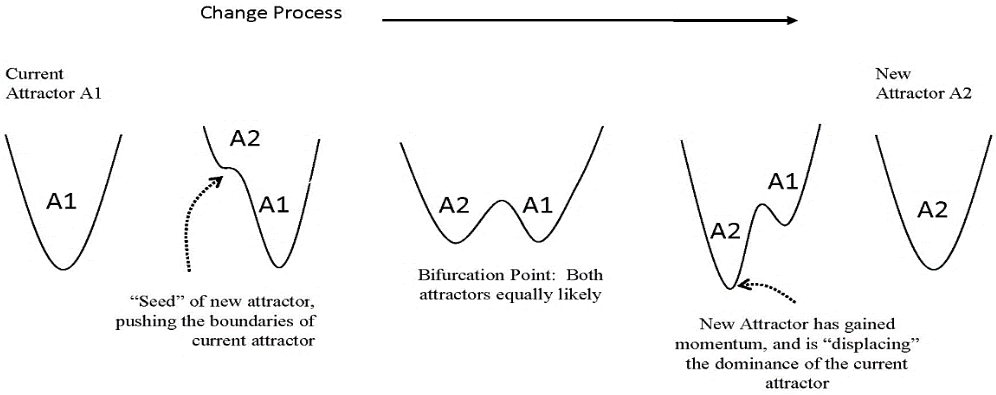

Figure 4.5: Changing 'Attractor Basins' around Stability points, with one Parameter Constant from (Lindhult & Hazy, 2016).

By using attractors, manager cannot direct the charge of the change because the new pattern of the attractor cannot be precisely defined but it is possible to nurture the elements of the new context and create conditions under which the new conditions can arise (Ramalingam *et al.*, 2008). Morgan sees that the power of this approach lies in its potential both to open up new understandings and possibilities for action but also, importantly, to outline the limitations in terms of individual actors' control and power over organisational change processes. In this dissertation the innovation ecosystem is the dynamic system and hence an attractor can be any event, activity, technology organisation or institution that spurs the ecosystem to innovate. The premise is that even if a system is subject to unpredictable attractors, one can still predict that the system will remain within certain boundaries (Hazy, 2011). These boundaries are known as an *attractor cage* where actions and choices by agents undertaken in such boundaries is from locally relevant information. So for an enlightened manager of such a system, when an attractor occurs they should firstly ask how the unexpected event came about and the contextual factors around the attractor (Hazy, 2011). Insights into attractors may assist future decision making regarding a particular system.

4.3.2 Leverage points in CAS

Another way of identifying key turning points in a complex system is the concept of leverage points proposed by Meadows called leverage points and align very closely with the notion of attractors. These are key points in the system's structure where micro changes can result into macro results when an intervention is applied, i.e. a system drastically changes from small shifts from points of power (Meadows, 2008). Meadows outlined that these points are often not intuitive and outlined 'places to intervene' in a system according to increasing order of effectiveness in 12 levels. These grow from outlining the constants and parameters of the system (e.g. tax, subsidies), to abstract ideas of shifting paradigms and mindsets (e.g. the value created by the system). These leverage points for change are shown in Figure 4.6.

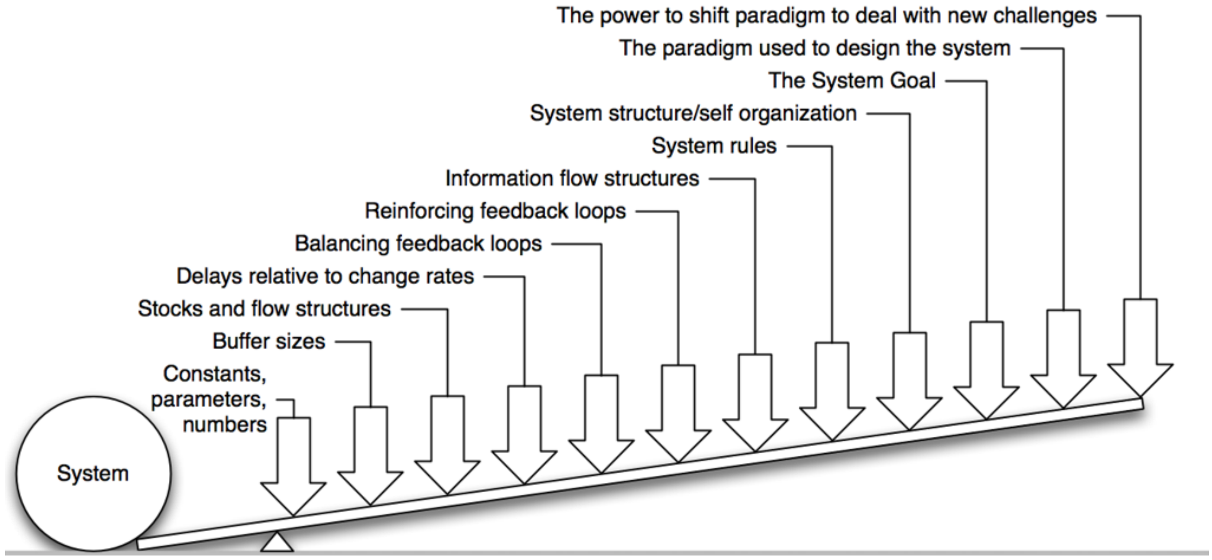

Figure 4.6: Leverage Points of a System. Source:(Meadows, 2008)

Expansion of each of these leverage points is shown in Table 4.1, below categorised into the physical, informational, social and conscious layers.

Table 4.1: Categorisation of Leverage Points from (Meadows, 2008) and (Roxas, Rivera & Gutierrez, 2019)

Type	Lever	Aim
Physical	10. Stock-and-Flow Structures: Physical systems and their nodes of intersection 11. Buffers: The sizes of stabilizing stocks relative to their flows 12. Numbers: Constants and parameters such as subsidies, taxes, and standards	• Focus on changing inputs • Focus on more proximal drivers _Note: Low leverage potential_
Informational	9. Delays: The lengths of time relative to the rates of system changes 6. Information Flows: The structure of who does and does not have access to information 7. Reinforcing Feedback Loops: The strength of the gain of driving loops 8. Balancing Feedback Loops: The strength of the feedbacks relative to the impacts they are trying to correct	• Reduce system delays • Examine stabilizing/ resisting influence of balancing feedback loops • Reinforce virtuous feedback loops • Explore and alter *who* has access to *what* information
Social	3. Goals: The purpose or function of the system 4. Self-Organization: The power to add, change, or evolve system structure 5. Rules: Incentives, punishments, constraints	• Understand and change what the rules are and who has power over them • Nurture innovation, flexibility, variation and collaboration _Note: High leverage potential_
Conscious	1. Transcending Paradigms 2. Paradigms: The mindset out of which the system—its goals, structure, rules, delays, parameters—arises.	• View whole system functioning and dynamics • Expose anomalies and failures in old paradigm and challenge assumptions • Work with active change agents _Note: Highest leverage potential_

The extent of potential leverage points range as having weak, medium or strong leverage on the system (Roxas *et al.*, 2019). This is a shift from mere causality to teleology. This study aims to harness both dimensions, of which the range of bias to either perspectives is based on the ecosystem being studied. Understanding sustainability through the identification of these particular leverage points is important as a leverage points perspective recognises the influential leverage points relating to any changes in the system and assists in transformative change (Fischer & Riechers, 2019). Sustainability interventions have mainly addressed highly tangible interventions which are deemed weak leverage points due to limited potential for transformational change (Abson, Fischer, Leventon, *et al.*, 2017).

Advantages of using a leverage points perspective outlined by Fischer and Riechers (2019) include:

1. Bridging the causal and teleological explanations in system changes as variables influence each other.
2. Recogintion of explicitly 'deep' leverage pointers –which are places that need attention or where interventions are difficult.
3. Leverage points enable the examination of interactions between shallow and deep system changes.
4. Leverage points can act as methodological boundaries and provide a way for interdisciplinary academics and societal stakeholders to collaborate.

Emphasis has been for research to be centred around three realms of leverage i.e. re-connecting people to nature, re-structuring institutions and re-thinking how knowledge is created and used in guiding humanity towards sustainability (Abson *et al.*, 2017). This study is aligned with this discourse through the innovation ecosystems lens and relooking at what exactly are the core activities that shift the ecosystem in different directions.

Their research framework, where the leverage points are grouped as *material* pertains to parameters that are mechanistic and modifiable such as incentives and standards; *feedback* are the interactions between the system elements that drive the internal dynamics of the system: *design* characteristics are the information flows, rules and self-organisation and *intent* aligns with the values, goals and norms embodied in the system. The interlink with Meadows 12 leverage points is shown in Figure 4.7 below:

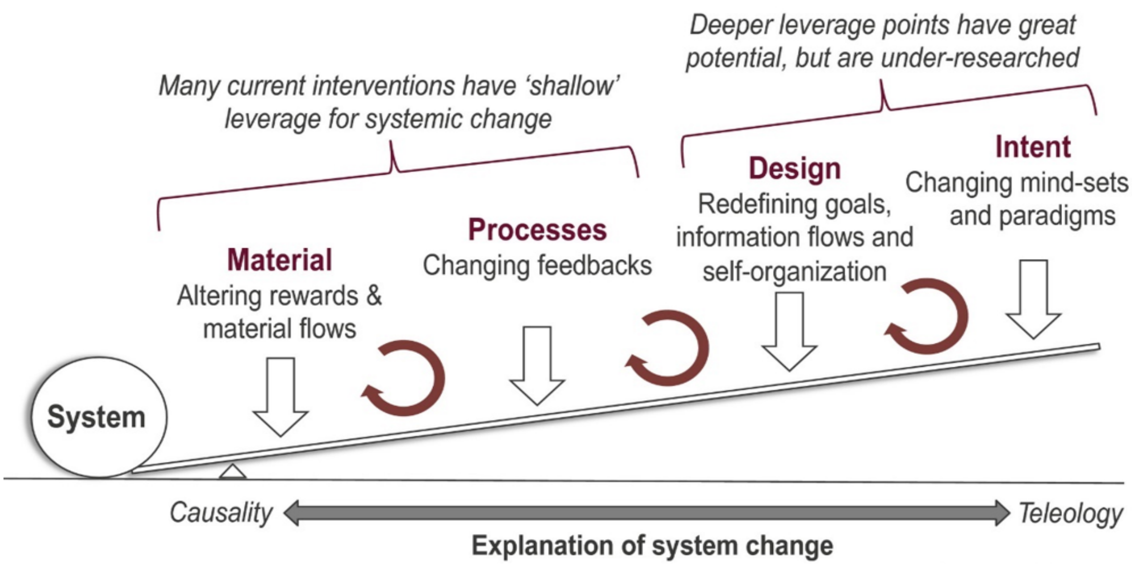

Figure 4.7: Leverage Points Research Framework. Adapted from (Abson *et al.*, 2017)

Leverage is not a new term when it comes to research aligned with the term ecosystem especially those that align with platforms. Thomas *et al* (2014) aligned the concept of leverage with relation to platform ecosystems through a review undertaken on platform literature. The distinct leverage they identified was categorised under production, innovation and transaction leverage and how platform ecosystems exhibit all three aspects with relation to the openness that the platform's architectural openness which has ranges. In their review they noted that in the context of strategic management, leverage is a direct driver of value creation and competitive advantage, as it provides a mechanism to achieve greater outputs from the same level of inputs, other things being equal. This competitive advantage can be reflected in systematic activities such as reduced process costs, increased revenue, or market dominance.

Thomas et al., (2014) suggested that a platform can be analysed and assessed by looking at the '*architectural leverage*' of a platform. This incorporates 'theoretical logics of leverage' and 'architectural openness'. Leverage is when in a system the impact generated is larger than the input in the system. In platforms, leverage is attained through the recombination of shared ideas, standards and assets by actors sharing the platform through coordination and collaboration (Thomas *et al.*, 2014). It is done in three ways leverage through innovation, production or transactions. A diagram of these characteristics is shown in the tree diagram in Figure 4.8.

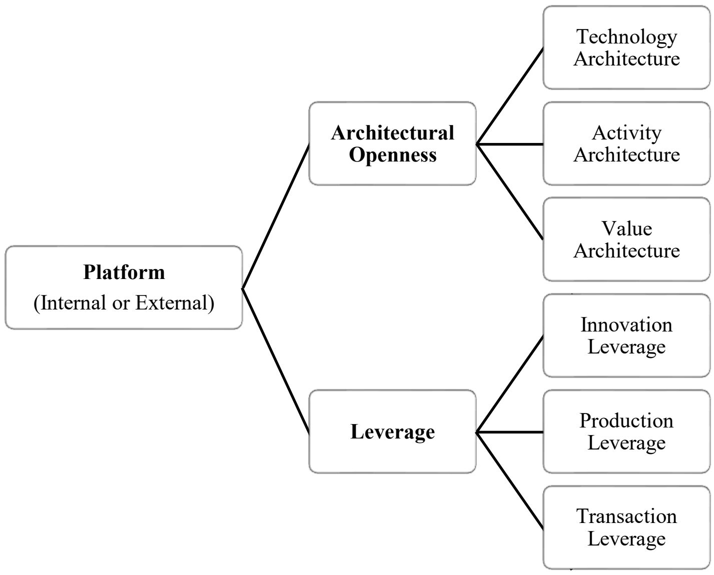

Figure 4.8: Platform Characteristics, Derived from (Gawer & Cusumano, 2014; Thomas *et al.*, 2014)

Architectural openness refers to the accessibility and the openness of the architecture of the platform. This can be explained from three different levels which are technological architecture, activity architecture (Thomas *et al.*, 2014) and value architecture (Schreieck *et al.*, 2016). Technological architecture address issues regarding design while activity architecture pertains to who will have access to the platform. Activity architecture is linked to the structure and composition of ecosystems that emerge around the core platform and coordination dynamics which contribute to the value creation dynamics. Platforms are distinct in their association with network effects (Gawer & Cusumano, 2014).

Platforms evolve through different logics of leverage and openness which assist in looking at an innovation ecosystem. For an innovation ecosystem by understanding the design principles of shared platforms (*technology architecture*) it enlightens the platform owner or intermediary on the important roles in the ecosystem. This influences who was able to connect to and benefit from the platform (*activity architecture*) and the resulting value that is created (*value architecture*). Thus, in ecosystems it is important to look at the types of platforms and distinguishing the different types of leverage and theoretical constructs of architectural openness in platforms. This is something that this study considered. In a space of value co-creation, structural flexibility and integrity ensue tensions; shared institutional logics can assist actors that may have a cognitive distance apart and a common set of rules (architecture of participation in the ecosystem (Lusch & Nambisan, 2015). Sharing these views in the ecosystem ensures that actors interpret resource integration opportunities coherently and come together quickly to exchange or integrate resources (Lusch & Nambisan, 2015), which, in short, is to create values for the ecosystem.

What is true is that the definition of leverage that Thomas and Autio (2014) use of it being "*a process of generating an impact that is disproportionately larger than the input required* " (Thomas *et al.*, 2014: 206) aligns with the way Meadows (2008) uses it also. Thomas and Autio (2014) reflected how leverage is achieved in firms interacting through the same platforms through the facilitation of governance by developing shared assets, designs and standards. They reinforced the importance of this study by highlighting that there has been little or no work and distinguishing between different types of leverage and exploring the theoretical underpinnings of the concept.

4.4 Identifying Change Attractors and Leverage points

Attractors and leverage points have been investigated and represented in various ways. Most of the studies on attractors have come from a mathematical modelling point of view both on a micro and macro-level. Such modelling is seen as a potential research direction that can assist innovation ecosystem modelling and usage of data that is available amongst actor interactions on technology-centric platforms (Ritala & Gustafsson, 2018). Though this is fundamentally important, that is not the focus of this study. Of importance to this study is utilising the CAS lens in qualitative studies. The application of aspects of CAS outside mathematics is not new but the deliberate application of chaos and complexity theory in the management of organisations is still a developing field (Obolensky, 2016).

The procedure of how exactly to use the attractor metaphor especially in management literature from a qualitative perspective has various approaches. This is of importance as this study is of a qualitative nature and hence the usage of the term must be clearly outlined and verified as part of the framework. A summary of some identified studies from various fields is shown in Table 4.2. These studies were selected due to the usage of the attractor metaphor and construct in qualitative studies, but more importantly, because they clarify how the attractors were identified. Notably, they were not directly aligned with innovation ecosystems but more with various system perspectives on actors and stakeholders.

Table 4.2: Methods for extracting attractors

Author	Context	Methodology and Procedure for extracting attractors	Type of attractor identified
(Dolan, García, Diegoli, *et al.*, 2000)	Organisational Management	• Define strange attractor set of values	*Strange attractors:* capacity for self-organisation derived from how their members accept a shared set of values or principles for action (Management by Value)
Mattsson et al (2005)	Tourism	• Surveys • Comparative case studies	*Structural attractors:* event, activity, organisation or the like that attracts people to the tourist attraction-Model of scene maker/scene taker/network between firms
(Gilstrap, 2005)	Education	• Bottom -up method for connecting metaphors with Complexity Science • Incorporate strange attractor metaphor through team processes	*Point attractors:* copies of a syllabus, established universities *Periodic-point attractor:* photocopying syllabi *Strange attractor:* shared vision, team processes, information flows
Haynes (2008)	Public policy	• Spatial and temporal analysis of the historical context of social care • Case study	*Strange attractors:* market managerialism, marketisation, privatisation, personalisation and consumerism
McDonald (2009)	Tourism	• Case study • Complex Systems theory terms as a framework	*Social attractors*: by values, conflicts, issues or perceptions social, political and cultural issues influencing behaviours within the system were identified
(Palmberg, 2009)	Organisational Management	• Literature review of CAS • Inductive and interactive approach	Identify system holder to *create attractors*, visioning and setting simple rules and maintaining feedback systems
Mol (2010)	Tourism	• Case study drawing • Used ecological modernisation theory and the sociology of networks and flows around megaevents	*Global attractors:* sustainability around Megaevents
Hatt (2013)	Natural Ecosystem	• Qualitative nonlinear methodology • Diagram of nonlinear loops, analysing eco-social relations through feedback loops	*Ecological attractors:* benthic and pelagic *Social attractors:* nature, property, conservation
Lythberg et al (2015)	Manufacturing	• Documents analysis of culture and history of the Māori community	*Structural attractors* - Māori community
(Newth *et al.*, 2017)	Business Model Innovation	• Case study • Long-term participant observation *(meetings, informal conversations, organisation work)* • 16 interviews	*Structural attractors:* organising constructs e.g child sponsorship, business model, blended value logics
Braa et al (2017)	Healthcare	• Concept of cultivation • Analyse actor interaction	*Change attractor*: Technology platform
Kuhmonen (2017)	Agriculture	• Future images • Participant workshops	*Structural attractors*: Identified 10 regional attractors

Dolan et al (2000) identified how the way management is undertaken determines how an organisation effectively deals with complexity, chaos and turbulence. Giving orders (*Management by Instructions*) or defining objectives (*Management by Objectives*) have the tendency of not building lasting changes as there is no change in the organisation's principal philosophy. Hence, they suggested *Management by Values* which incorporates a cultural change from either final or instrumental values. This gives rise to the identification of the attractors such as work with flexibility, creating social responsibility and generating trust. In the tourism industry, Mattsson et al (2005) carried out a few comparative case studies to pinpoint the attractors. They developed a model to show the steps and functions in the exploitation of the attractor that includes the actors and the innovation intermediaries. In this study an attractor was an event, activity, organisation or the like that attracts people to the tourist attraction. It was reiterated that the main purpose of the attractors was to create attention and they do not need to be industry specific and have anything to do with tourism.

McDonald (2009) outlined how to use complexity science to understand sustainable tourism development using strange attractors. The aim was to gain understanding of the system in which tourism operates and how it is affected by values, conflicts, issues or perceptions of the community which would help to understand why sustainable tourism development is problematic. They built a framework to understand underlying values that people associate with stakeholder issues or behaviours in sustainable tourism. On the other hand, Mol (2010) used complexity science in an *instrumental* way. This was moving away from the mathematical formulations and looking at the socio-technical aspects that evolve around the identified attractor. The aspect that was under study was the concept of sustainability as a global attractor, where the case study was on how mega-events act as points of convergence which cause a global shift across norms in the environment, democracy, transparency and equality. The main aim was advising how sustainability can become institutionalised in material and social infrastructures to have permanency when a mega event such as The Olympics or World Cup ends in a community or country.

In a healthcare context, Braa et al (2017) looked at how the introduction of a dashboard in a health information system was a means to get different stakeholders to discuss and reach a consensus on how to integrate and share data without disturbing the underlying systems. The concept of CAS was utilised to understand the problems of fragmentation and poor coordination in the Indonesian Health Information System. They used the concept of cultivation where the gradual development of a technological platform proceeds through 'cultivating' user participation, tinkering, improvisation, over time. In this case the platform was the attractor that may be used as a strategy to enable cultivation of user participation, experiments around practical prototypes and shared learning-by-doing among users and developers.

From a business model perspective, Newth et al (2017) suggested complexity thinking and the use of structural attractors as an additional theoretical lens which might shed light on the challenges of change, social innovation and bases of resistance to social entrepreneurship in Non-Governmental Organisations and Non-Profit Organisations. They used structural attractors to explain the challenges in business model development for hybrid organisations through using the World Vision New Zealand branch as a case study. Child sponsorship was identified as the core structural attractor that offers the historical social logic, drives the business model as the main source of revenue and constrained the development of blended value opportunities.

Gilstrap (2005) utilised metaphors from how strange attractors function in educational leadership. The study provided methods for identifying and using strange attractor metaphors to facilitate emergent, complex educational environments. The strange attractors were described in organisational settings as shared vision, team processes, information flows and positive feedback mechanisms. Hatt (2013) mapped out a nonlinear strategy for conceptualising and operationalising social attractors. It began with the description of the specific situations involving social and ecological relations amongst actors. The analysis included nonlinear causal-loops diagrams with positive or negative feedback loops expressing major social issues and linking them to social attractors, shown in **Figure** 4.9. This was done to assess the relative tendencies and potential in the situation. Five attractors were identified comprising of two ecological and three social attractors aligned with conservation, nature and property.

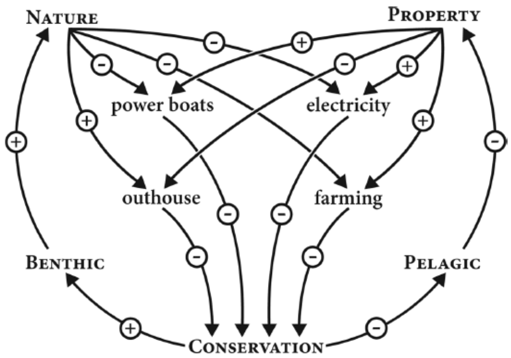

Figure 4.9: A Nonlinear Model of Ecological and Social Attractors (Hatt, 2013).

Kuhmonen (2017) conducted a study where the aim was to highlight the various nodes and milestones towards which the behaviour of actor or agents in Finnish food systems navigate and accumulate. They used the concept of 'futures images' which are an expectation about the state of things to come in the future. The futures images provided the alternative futures that explored how the food systems can be made sustainable through maximising the economic, environmental, social and cultural perspective. Data was collected through four regional three-hour workshops to observe the socio-economic, cultural and environmental circumstances surrounding the systems. In each of the workshops region specific futures images were crafted and presented to workshop participants and rated in terms of high or low probability, possibility and desirability. The key points of the futures images had been found from an extensive literature survey. The outputs of the workshops were analysed through content analysis without predefined categories to expose the attractors.

Lythberg et al (2015) looked at the Māori community complex as a structural attractor that shapes entrepreneurial activity. This was done in looking at two frameworks that embodied the enterprise leadership and culture of the Māori. Some aspects included considering how aspects like historical events, e.g. colonisation, and the formation of cooperating groups affect the innovation process and indigenous entrepreneurship. Their main definition was aligned with how a structural attractor is an artefact that shapes interaction patterns of complex systems of human interactions.

From the dynamic properties of CAS and how attractors are utilised in variety of studies outlined above, it was deemed a futile exercise to just produce a list of what the attractors and leverage points are as that would become more directive and overshadow the way that the systems evolve. Hence the author, instead opted to highlight the process of how an attractor or leverage point can be utilised as a summation of the learnings from the studies.

Using Causal Loop Diagrams to Identify Leverage Points and Attractors: The aim remains to explore how attractors can be identified from the systemic narrations, historical actor interactions and different occurrences around the ecosystem. This can be done in various ways in systems thinking and methodologies. Building from the studies examined above, the suggested procedure of identifying attractors and leverage points can be looked at in a system from three distinct stages:

1. *Aspect identification*: This involves selecting what aspect is to be looked at in the system and what dynamics are being looked at in the (eco)system. This can be the system management, artefacts such as technology usage or communities.
2. *Boundary alignment:* This involves looking at what key dynamic in the (eco)system is under investigation or the system relations between the actors and how they change and respond to various attractors.
3. *Sensemaking:* select a relevant procedure and method for extracting and identifying what the attractors that are influencing relational behaviours amongst actors is in the (eco)system.

If a database of events has already been outlined, then a depiction of how the events affect each other is important. One common way is the use of Causal Loop diagrams (CLDs) to identify the leverage points (De Pinho, 2015; Fischer & Riechers, 2019; Nguyen & Bosch, 2013). Identification of these points all were aligned with sustainability of the system. Identification of potential leverage points in causal loop diagrams can be aligned with satisfying the following criterion outlined by (Roxas *et al.*, 2019). A leverage point as shown in Figure 4.6 :

1. can be a common cause to multiple effects that can accelerate or decelerate the operation of a system –aligned with the physical leverage points (9-12).
2. can be influenced by an intervener and hence change the system – aligned with the information and control leverage points (4-8).
3. is the root cause characterised by being independent and hence cannot cite further causes – aligned with the idea and conscious leverage points (1-3).

An example of such identification is shown in Figure 4.10 where the points that have an influence and are leverage points have been highlighted and hence can inform the managers of the system from a study in conservation. This will be the depiction that will be utilised in this study to help inform the framework.

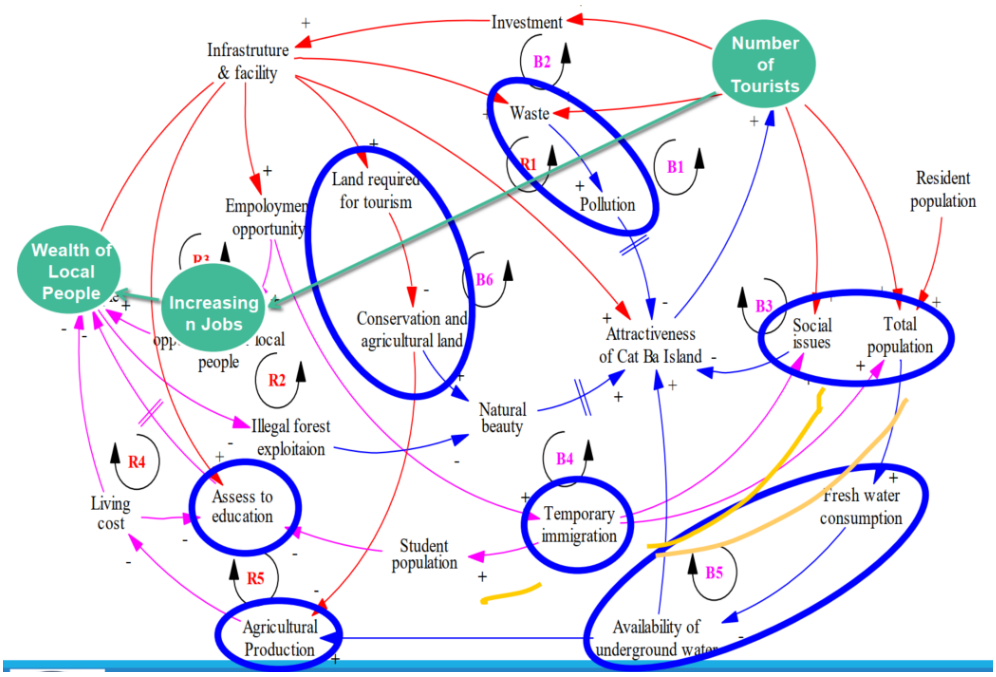

Figure 4.10: Example of Leverage Point Identification from Robert Steele[11]

In this study, as an innovation ecosystem is identified as the CAS, the main aim is to promote and increase value co-creation dynamics amongst actors. The study aligns with the integrated definition that attractors/leveraging points are agents or functional activities that influence the ecosystem to act in a particular way, moving the ecosystem to more desirable states and hence affect the emergence, evolution and growth of the ecosystem (Braa and Sahay, 2012; Cilliers, 1998; Kuhmonen, 2017; Mitleton-Kelly, 2003). The key assumptions in this study when it comes to leverage points and attractors are:

i. The attractors/leverage points are important activities that have been identified as key to turning points in the ecosystem.
ii. Attractors/leverage points are the core, robust and most stable elements of innovation ecosystems that determine how interactions are carried out in the ecosystem and thus affect the dynamics in ecosystems.
iii. The attractors are identified through other CAS characteristics of historical reference and pattern formation where lessons are learnt based on the functional activities occurring in the ecosystem.
iv. The leverage points and attractors in the ecosystem are informed by the innovation systems functions mentioned in Chapter 3. Of note is that the identification of the attractors must acknowledge the systemic and evolutionary states that occur in an ecosystem. Notably, in as much as the guiding functions and activities seem static, each innovation ecosystem exhibits different focal attractors that affect ecosystem evolution. In a way, this aligns with a grounded theory perspective of letting the innovation ecosystem timeously give feedback to the innovation ecosystem manager.

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[11] presented Expert Consultation on Implementing the 2030 Agenda for SD in Asia Pacific
https://www.unescap.org/sites/default/files/Session%202.%20Identifying%20leverage%20points_0.pdf

In this study, from this point forward there will be reference only to leverage points so as to not have any confusion in interchanging terms.

4.5 Chapter Conclusion

This chapter outlined how an innovation ecosystem exhibits the characteristics of CAS. Figure 4.11 summarises the CAS attributes that will be utilised in the study as pointers for ecosystem analysis as a point of reference in the study. How it cumulatively integrates with the rest of the theoretical aspects that were discussed in previous chapters where the full outline will be discussed in detail in Chapter 7.

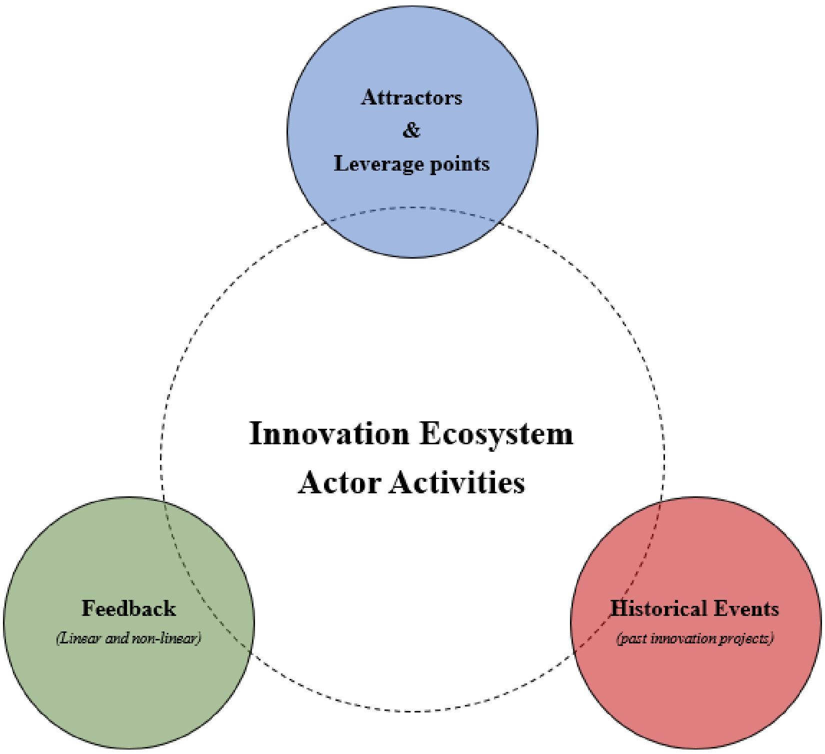

Figure 4.11: Innovation Ecosystem Actor Activities aligned with CAS

Using attractors to guide ecosystem management aligns with the call to move past using CAS only for interpretive purposes (Jucevičius & Grumadaitė, 2014) and advancing rigorous assessment guidelines for innovation ecosystems (Gawer & Cusumano, 2014; Ritala & Gustafsson, 2018). It serves as the core skeleton for the conceptual framework for this study. The next chapter will address what innovation intermediation is and how its assists in the value co creation and appropriation process of innovation ecosystems. This comes from the assertion by Obolensky (2016) and Braa et al (2017) that though CAS cannot be directed they can be managed, and in this study that management is through innovation intermediaries.

Chapter 5: Innovation Intermediation for Innovation Ecosystem Sustainability

"*Without change there is no innovation, creativity, or incentive for improvement. Those who initiate change will have a better opportunity to manage the change that is inevitable.*" — William Pollard

This chapter shows how the innovation intermediation is not a common but necessary concept in innovation ecosystem emergence and management.

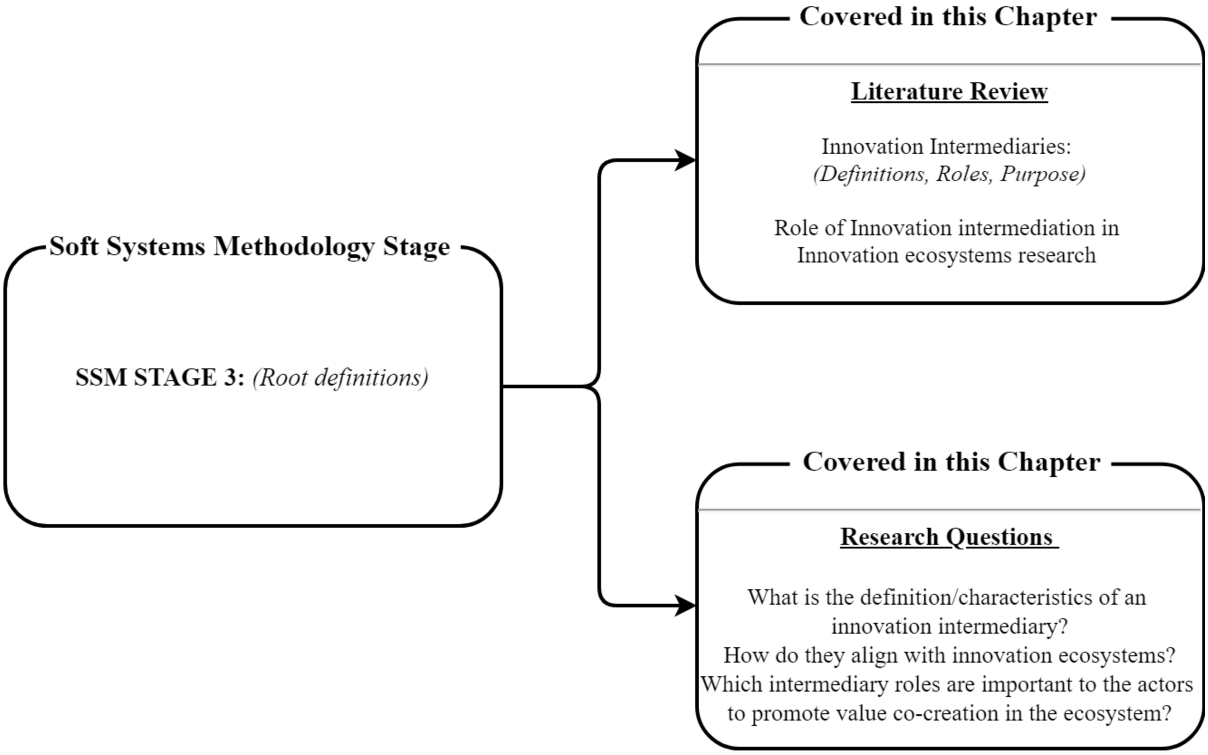

Figure 5.1: The Structure of Chapter 5 within the Context of the Soft Systems Methodology.

5.1 Understanding Innovation Intermediaries

As mentioned in the previous chapter, though a complex system cannot be directed it can be managed, in this case through innovation intermediation. To better understand innovation intermediation in this study, a systematised review was undertaken to ensure that the study is grounded in recent existing literature on the role of innovation intermediaries, their functions and how they can assist in the value creation process of actors in innovation ecosystems. This chapter presents a picture of the innovation intermediary makeup, functions and roles, and assesses how studies are addressing the problem of complexity when it comes to innovation intermediation in the context of innovation (eco)systems. The aim is to identify and elaborate on the dynamic nature and roles of innovation intermediaries in the innovation process amongst ecosystem participants to inform on innovation ecosystem emergence and sustainability.

5.1.1 Intermediation Literature Review design and search protocol

For the review, Tranfield's (2003) framework for conducting a systematic literature review was integrated with the meta-narrative review phases as mentioned by Greenhalgh (2005). This resulted in more of a systemised review as this review was undertaken by one researcher; a full comprehensive systematic review would require a substantial number of researchers (Tranfield *et al.*, 2003). The selected peer reviewed journal articles were from the Scopus and ScienceDirect databases. The steps are shown in Figure 5.2. The search terms were initially 'innovation' and 'intermediary' then the term 'innovation ecosystem' was used as a filter in the search criteria. The inclusion and exclusion criteria were in two categories. Category 1 (C1) excluded panel discussions, conference reviews and lecture notes and any articles not written in English. Category 2 (C2) entailed reading through the abstracts and assessing the empirical soundness of the study relating to dynamics around (eco)systems and intermediation. The review included documents that were searched from November 2017 to April 2020. The list of the papers is shown in Appendix B.

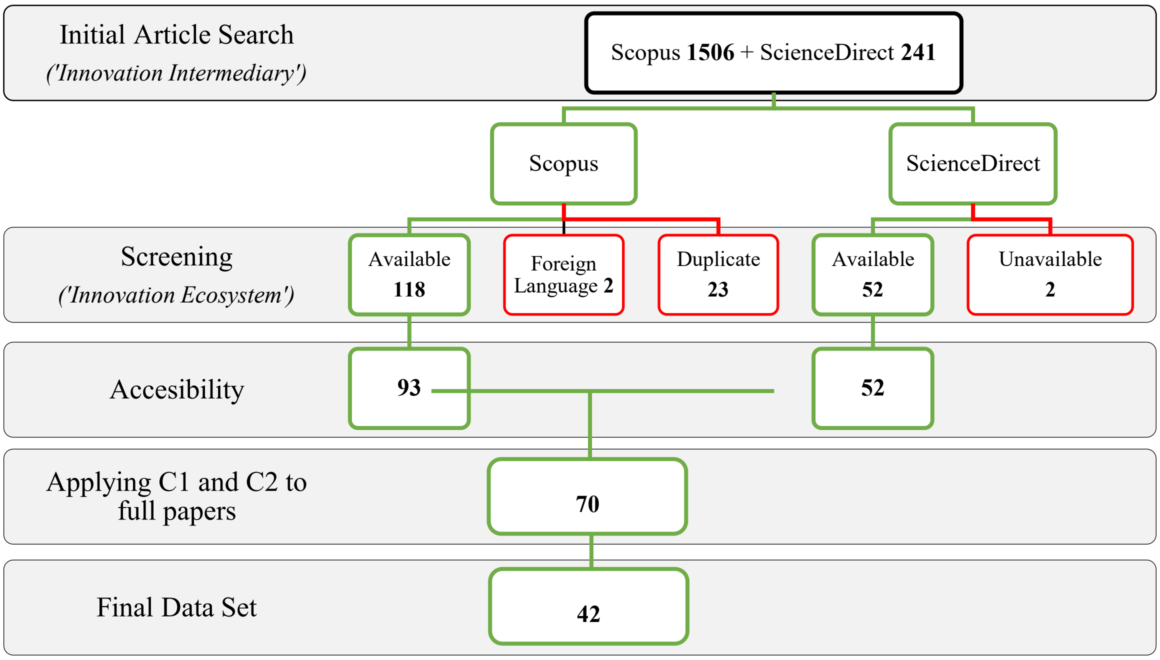

Figure 5.2: Literature selection[12]

The descriptive and interpretive analysis from the review are outlined below. Descriptions of the timeline, types of articles and focus areas are presented. Then a cumulative interpretive analysis was done to give an overview of the definition of innovation intermediaries and how intermediation has been utilised in systems. Throughout the discourse important aspects that are key to the study framework will be highlighted.

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[12] Some authors who kept the same sentiment and theoretical constructs across papers were removed from the review papers for only unique referral points. Examples for this were (Klerkx, Álvarez & Campusano, 2015; Klerkx, Hall & Leeuwis, 2009; Klerkx & Leeuwis, 2008a).

5.1.2 Descriptive statistics

5.1.2.1 Publication Methodology

A total of 42 publications were analysed of which 38 were journal articles. The most prevalent methodology was qualitative case studies due to the exploratory nature of most of the studies. This is not surprising as especially when it comes to concepts aligned with innovation ecosystems, it has been noted that most studies tend to be descriptive. This can be attributed to the socio-technical contexts that most of the studies were based around which also contributed to the roles that were identified and outlined. Identification of the methodology was important in this review in order to place the study and ascertain the best type of methodology that can be best used in order to move past descriptive studies. The different types of methodologies are shown in Figure 5.3, which shows the number of studies attributed to each research methodology.

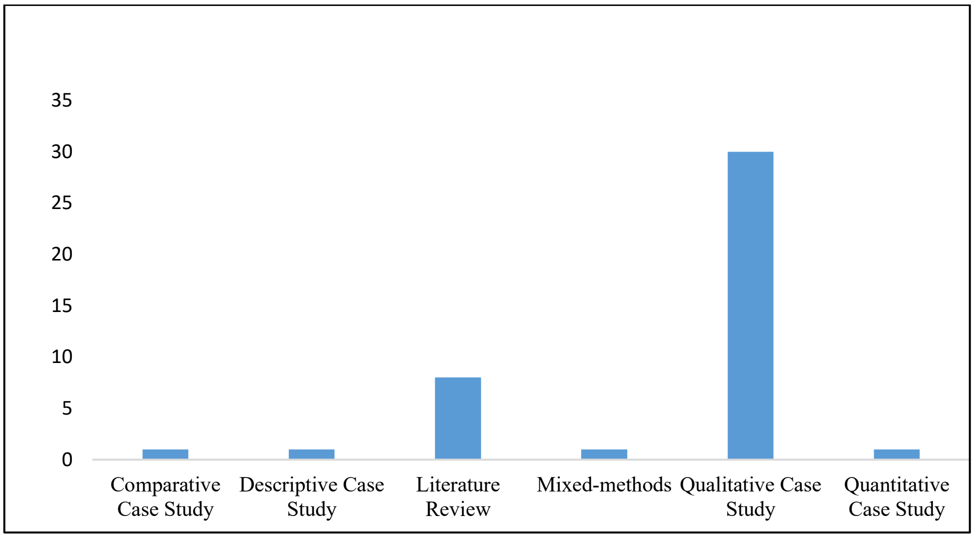

Figure 5.3: Review Articles Study Methodologies

5.1.2.2 Type of Intermediation in publications

Another element that distinguished the studies was the type of intermediary that was under investigation in the case studies, shown in Figure 5.4. The most prominent cases were those of technology platforms (24%), comprising of various activities aligned with collaboration, competition and cooperation. There was mention of human and software agents acting as intermediaries together where each agent compliments each other. Some studies included a mixed group of case studies hence no distinction was made.

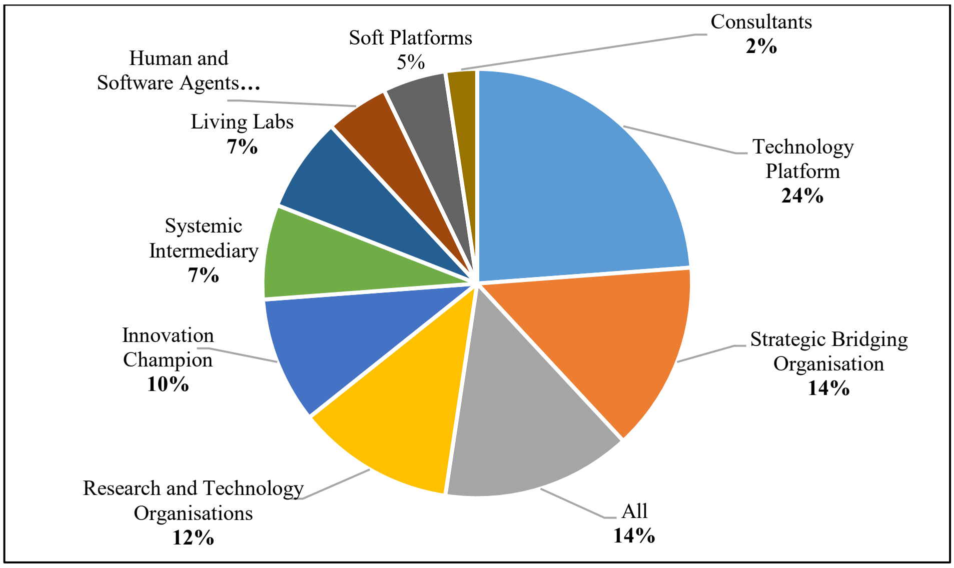

Figure 5.4: Type of Intermediation in Review articles

5.1.2.3 Context and Focus Area of Publications

The study focussed on the study context and the central theme of the reviewed publications. The cumulative categories are shown in Figure 5.5. 14 of the studies in the review focusses on the attributes and description of the intermediary which is termed intermediary typology in the study. This adheres with one of the most common research gaps for innovation intermediaries that states that more studies should focus more on empirical work than just listing attributes and capabilities. Of interest are the 7 studies that look at the integration of innovation (eco)systems with Technology Innovation System functions.

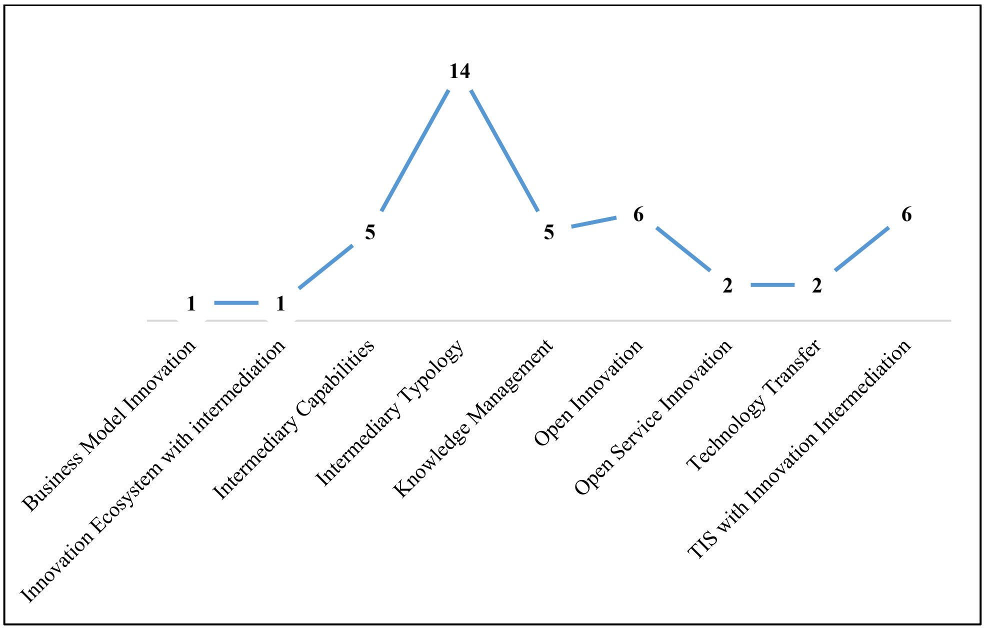

Figure 5.5: Study Context of Review Articles

5.2 Intermediary Characteristics

5.2.1 Innovation Intermediary Definition, Types and Characteristics

The innovation intermediation concept is one that has been utilised and mapped out across various industries. The classification in this review is shown in Figure 5.4. The classification is usually aligned with either the purpose of the intermediary (e.g. matchmakers brokers, mediators, information hubs); the physical attributes with relation to the system (e.g. meta-organisations, bridging organisations, research and technology organisations); or the part they play in the innovation process (e.g. information agents, strategic intermediaries, platform intermediaries, transition intermediaries, knowledge intermediaries, diffusion intermediaries, financial intermediaries, market intermediaries) (Abbate, De Luca, Gaeta, *et al.*, 2015; Bergek, 2020; Bessant & Rush, 1995; De Silva *et al.*, 2018; Howells, 2006; Kivimaa & Martiskainen, 2018; McMullen & Adobor, 2011; Thomas *et al.*, 2014).

This can range from human agents/consultants (Bessant & Rush, 1995; Klerkx & Aarts, 2013), universities and public entities (De Silva *et al.*, 2018; Schröter, Matzdorf, Sattler, *et al.*, 2015), private organisations (Hossain, 2012) and technologies or platforms (Abbate, Codini & Aquilani, 2019; Datta, 2007; Janssen, Bouwman, Buuren, *et al.*, 2014; Munthali, Leeuwis, van Paassen, *et al.*, 2018; Randhawa, Wilden & Gudergan, 2018; Thomas *et al.*, 2014). Moreover, with diverse geographic configurations intermediaries are now actively engaged in that process of co-creation in the innovation process resulting in intermediaries being termed meta-organisations (Radnejad, Vredenburg & Woiceshyn, 2017). Though they are diverse types of intermediary classifications, the consensus amongst the authors is on what intermediaries do (Bergek, 2020). Stewart and Hyssalo (2008) emphasised intermediation through the creation of spaces and opportunities where Weng (Weng, 2017) noted that it can be done directly through a direct relationship or indirectly through enhancement of the innovative capacity of ideas, knowledge or technologies (Stewart & Hyysalo, 2008; Weng, 2017).

Howells (2006) did a review and put forward a tentative definition that an intermediary is *"an organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations"* (Howells, 2006: 720) **.** Intermediaries act as diffusion and technology agents that facilitate, broker or mediate between homogenous actors quite close to each other across the value chain (Agogué *et al.*, 2013; Stewart & Hyysalo, 2008). Initially as Howells outlined, an intermediary was required to act as only a facilitator or enabler and not focus on the generation or implementation of innovations (Klerkx & Leeuwis, 2009; van Lente, Hekkert, Smits, *et al.*, 2003). Innovation intermediaries are not typically technology or product providers (Brown, Kivimaa & Sorrell, 2019). Instead of being clearly defined at the beginning, innovation intermediaries can be emergent as the types of ecosystem needs change across each growth stage (Hakkarainen & Hyysalo, 2016; Stewart & Hyysalo, 2008). This is known as the 'ecologies of intermediaries' which change during different stages of the system (Stewart & Hyysalo, 2008).

Structurally, intermediaries are categorised in two distinct categories; traditional and systemic intermediaries (van Lente *et al.*, 2003). Traditional intermediaries can be hard, in terms of individuals or organisations that have a bilateral function aligned with the management and policy-making that spurs innovation (Bessant & Rush, 1995). This also relates to communities of practice (Kilelu, Klerkx & Leeuwis, 2013). Such communities also necessitate the creation of innovative environments such as accelerators, living labs and incubators (Hakkarainen & Hyysalo, 2016). Systemic intermediaries tend to function on a network level with multilateral interactions. Such categorisations have not changed but there is a tendency to now look at the intermediary on a systemic level and move to a more collaborative effort than one organisation being the lead intermediary (Agogué *et al.*, 2013).

Intermediaries can also have degrees of involvement and specialisation in the innovation process. These have been termed championing or non-championing intermediaries (Martiskainen & Kivimaa, 2018). Intermediary organisations themselves have leaders championing, building relational capital, communication strategy, celebration and recognition and managing expectations (McMullen & Adobor, 2011). A championing intermediary is more focussed on processes and visioning activities and is aligned with systemic intermediaries guided more by the value proposition of the system (Klerkx & Aarts, 2013) whereas a non-championing intermediary is regarded as neutral and more focused on linking actors through learning or networking and acts for the good of the actors (Kivimaa, 2014). Other terminologies are to do with specialisation where dedicated intermediaries which focus in one sector, dispersed intermediaries that are specialised and dedicated to more than one sector. Integrated intermediaries are in one sector but not only involved in intermediation activities but also in the supply chain-they are unspecialised and narrow. Diversified intermediaries are both unspecialized and broad (Bergek, 2020). A summary of the types is shown in Figure 5.6.

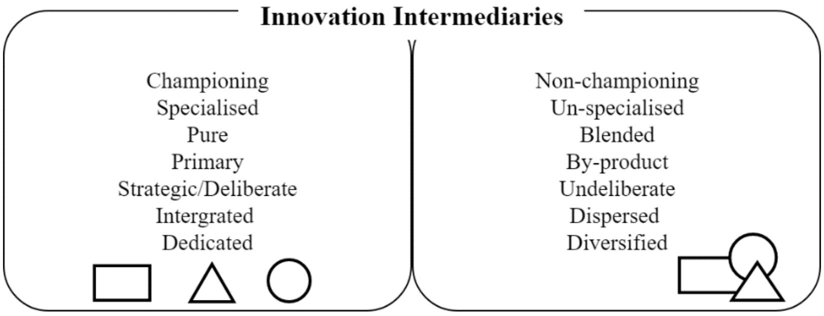

Figure 5.6: Different Types of Innovation Intermediaries Source: Author elaboration from (Bergek, 2020)

Aspects that hinder innovation intermediation and value co-creation can be aligned with inherent characteristics that intermediaries should exhibit. These characteristics align with articulation, alignment and learning (van Lente *et al.*, 2003). These can be grouped around physical systems, managerial systems, skills and knowledge as well as values (Janssen *et al.*, 2014). The core characteristics are:

1. *Absorptive capacity*: This is the ability of the innovation intermediary being able to identify, assimilate, transform, and use external knowledge (Knockaert, Spithoven & Clarysse, 2014) . To assimilate and internalise knowledge requires effort and hence innovation intermediaries are key in this process when it comes to an innovation ecosystem level (Kokshagina, Le Masson & Bories, 2017). Innovation intermediaries have issues that include receiving and handling enormous amounts of data. In addition they have timeline constraints on different initiatives that need to be delivered (Hossain, 2012). Hence, the innovation intermediary needs to be able to identify, assimilate, transform, and apply valuable external information (Bessant & Rush, 1995; De Silva *et al.*, 2018; Guo & Guo, 2013). This includes utilising knowledge-based practices in order to

build intrinsic value for actors in the ecosystem (Ardito, Ferraris, Messeni Petruzzelli, *et al.*, 2019; Datta, 2007; Håkanson, Caessens & MacAulay, 2011; Leeuwis, 2013).

2. *Social learning*: comprises being aware of how innovation takes place during diffusion of a service or technology in the system and domestication of the technology in the system (Hakkarainen & Hyysalo, 2016; Stewart & Hyysalo, 2008). In ecosystems, especially tech-centric one, there is usually adverse informality. Although informal interactions have benefits and lead to synergy, they may lead to knowledge being lost in the ecosystem or conflicts in interests amongst actors as communication is not clear. There is a need to have knowledge retention and learning processes in place (Klerkx & Aarts, 2013; Lauritzen Ghita Dragsdahl, 2017).
3. *Shared identity*: the intermediary is in the position to make sure that actors have common goals and clear expectations that merge with their individual interests (McMullen & Adobor, 2011). There is a need for shared norms amongst the ecosystem actors to achieve the main value proposition of the ecosystem (Randhawa *et al.*, 2018). This mitigates risk of opportunistic behaviour amongst ecosystem actors (Håkanson *et al.*, 2011). Identity also comes from acknowledgement of what the intermediary does in the ecosystem and how innovation intermediaries establish their roles (van Lente, Boon & Klerkx, 2020). Credibility in such roles has also been deemed as a mediator (Håkanson *et al.*, 2011).
4. *Power control and openness*: in managing the ecosystem various aspects of attracting and retaining actors involves levels of transparency, control of key resources, creativity and the appropriation and ownership of ideas (Lauritzen Ghita Dragsdahl, 2017; Randhawa *et al.*, 2018). When it comes to platforms there are aspects of architectural openness and leverage that enables actors to co-create (Thomas *et al.*, 2014). The intermediary has to have relational capabilities for building and maintaining relationships, developmental capabilities fostering skills and expertise and ethical capabilities that create sustained value (Randhawa *et al.*, 2018).
5. *Opportunity awareness and engagement*: The intermediary should have the ability to offer a strategic outlook to the actors and as well as online community engagement. Moreover, at times some institutional arrangements need to be in place to promote the value propositions of the ecosystem (Randhawa *et al.*, 2018).
6. *Technological capability*: Ideally, innovation intermediaries are not meant to define or control use of the technology. They can be a mix of human and software agents where the software agents "*embody complex functions that scan, collect, and structure data into visual depictions (e.g. cross tabs, pivot tables, plots) without requiring the user to learn the complex algorithms used in translation*" (Datta, 2007: 291). This aligns with enhancing the data processing capabilities that improve absorptive capacity dynamics (Schröter *et al.*, 2015). An intermediary can connect actors to address skill & competency gaps and other resource constraints that can be alleviated through utilising technological tools & functionalities (Randhawa *et al.*, 2018).
7. *Decentralised information collection and connective action*: When it comes to platform intermediaries both (soft, hard and systemic) decentralised information collection is important. This is because knowledge and learning are the main contributors to innovation and ecosystem sustainability (Chaminade *et al.*, 2018). This knowledge should be aligned with the value proposition of the ecosystem and be accompanied by a facilitated process of exchange and social learning to address collective problems (Munthali *et al.*, 2018). (Kivimaa & Martiskainen, 2018). Hence a range of technological platforms and tools are now being used to store information and knowledge that assists in strategic alignment of the ecosystem and also stimulate communities to innovate (Hossain, 2012).

The following section looks at the roles and functions of intermediaries that have been identified in the review.

5.2.2 Functions and Roles of Innovation Intermediaries

Innovation intermediation is of utmost importance when there is unpredictability of any technological change, market organisations, user uptake as well as a breakdown of linkages between potential users and suppliers that need to be created so that sustainable innovation can occur. They are responsible for establishing and fostering knowledge flows to reduce uncertainty and asymmetries between industry actors. Intermediaries supposedly create new networks, crafting visions, engage in learning, influencing existing policy processes, creating new polices , pooling financial knowledge and resources , managing process (Kivimaa & Martiskainen, 2018). The overarching roles were identified by Stewart and Hyysalo (2008) as facilitation, configuring and brokering.

Facilitation is described as providing opportunities to others by educating, gathering and distributing resources, influencing regulations and setting local rules (Hakkarainen & Hyysalo, 2016; Stewart & Hyysalo, 2008) Facilitation enables knowledge dissemination, support and co-ordination of the networks involved in the delivery of the value proposition and learning (Howells, 2006; Leeuwis, 2013; van Lente *et al.*, 2003). Configuration involves the design and modification of processes that promote the appropriation and adoption of social, technological and organisational innovations among key stakeholders (Howells, 2006). This covers technology configuration, business practices, content creation, rule setting and prioritising goals (Bergek, 2020; Kanda, Hjelm, Clausen, *et al.*, 2018). Brokering includes undertaking negotiations between different actors or on their behalf and raising support for the innovation process from suppliers, external sponsors or regulators (Howells, 2006; Klerkx & Aarts, 2013; Stewart & Hyysalo, 2008). This may include undertaking negotiation and advocacy activities to alter the institutional environment and can be termed 'market formation' (Kivimaa & Martiskainen, 2018).

Another main intermediary categorisation is demand articulation, matching demand and supply and innovation process managements (Klerkx & Aarts, 2013; Klerkx & Leeuwis, 2008b; Munthali *et al.*, 2018). Though the categorisations have ranged widely amongst scholars, the different activities aligned with each category are more or less the same across various studies. These roles and functions are context dependant (van Lente *et al.*, 2003), aligned with the stage of growth that the ecosystem is in (Agogué *et al.*, 2013; Janssen *et al.*, 2014; Martiskainen & Kivimaa, 2018; Randhawa *et al.*, 2018), and the past activities that have also occurred in the ecosystem (van Lente *et al.*, 2020). Table 5.1 shows a summary of the intermediary roles and functions.

Table 5.1: Functions and Roles of Innovation Intermediaries Author's addition to (Sovacool, Turnheim, Martiskainen, *et al.*, 2020)

Innovation Intermediary Roles and Functions	Activities	References
Knowledge Brokering Exploration (Knowledge and Learning)	• Knowledge gathering, processing, generation and combination • Facilitating experimentation • Combine knowledge amongst partners • Aggregation and circulation of knowledge • Innovation ecosystem knowledge shaping • Identifying and selecting actors with right characteristics	(Abbate *et al.*, 2015; Agogué *et al.*, 2013; Ardito *et al.*, 2019; Bessant & Rush, 1995; Brown *et al.*, 2019; Datta, 2007; De Silva *et al.*, 2018; Howells, 2006; Kilelu *et al.*, 2013; Stewart & Hyysalo, 2008)

Innovation Intermediary Roles and Functions	Activities	References
	• Motivating and retaining a critical mass of collaborators	
Capacity building	• Education: Training, skills development, links to external info • Strengthening actors • Provide advice and support	(Kilelu *et al.*, 2013; Kivimaa & Martiskainen, 2018; Stewart & Hyysalo, 2008)
Innovation resource integrator	• Marketing • IP Management • Tailored production advice provision	(Bessant & Rush, 1995; Brown *et al.*, 2019; Guo & Guo, 2013; Kilelu *et al.*, 2013; Stewart & Hyysalo, 2008)
Network building	• Formation and maintenance of innovation networks • Trust building and conflict resolution	(Howells, 2006; Kilelu *et al.*, 2013; Klerkx & Leeuwis, 2008b)
Brokering	• Representing actors and negotiating on their behalf • Communication amongst actors • Financial brokering by raising funds • Contractual advice	(Bessant & Rush, 1995; Brown *et al.*, 2019; Hakkarainen & Hyysalo, 2016; Howells, 2006; Kilelu *et al.*, 2013; Stewart & Hyysalo, 2008)
Co-creator /Co-designing	• Innovation process management • Technology Transfer (, technical problem solver • Technology spanner- connecting new technology and users	(Agogué *et al.*, 2013; De Silva *et al.*, 2018; Guo & Guo, 2013; Hakkarainen & Hyysalo, 2016; Kilelu *et al.*, 2013; Klerkx & Leeuwis, 2008b)
Visioning/Demand articulation	• Defining • (Technology) foresight and forecasting • Articulation of needs and requirements • Co-ordination and joint problem solving • Scanning and information processing • Identify innovation challenges and opportunities perceived by the various stakeholders	(Abbate *et al.*, 2019, 2015; Howells, 2006; Kilelu *et al.*, 2013; Klerkx & Leeuwis, 2008b; van Lente *et al.*, 2020, 2003)
Testing and Validation	• Testing, diagnostics, analysis and inspection • Prototyping and pilot facilities • Scale-up	(Abbate *et al.*, 2015; Howells, 2006)
Institutional Support	• Political advocacy and lobbying • Policy implementation • Legitimising institutional change • Developing standards • Developing work practices	(Abbate, Coppolino & Schiavone, 2013; Agogué *et al.*, 2013; Brown *et al.*, 2019; De Silva *et al.*, 2018; Hakkarainen & Hyysalo, 2016; Kilelu *et al.*, 2013; Stewart & Hyysalo, 2008) Agogue, abate, Hyssalo de silva, Hakk, Kilelu, Brown

With all the roles outlined, it comes to what they mean especially in this study and in the context of innovation ecosystems.

5.3 Innovation Intermediaries and Innovation Ecosystem dynamics

Complex systems are said to be managed and not directed, hence, an ailing ecosystem is usually characterised by the lack of an intermediary with a major challenge being how to coordinate ecosystem participants to work together (Autio & Thomas, 2014). The mechanisms of authority, command and control that are aligned with success of the individual firms rarely exist in ecosystem markets as the current business strategy has an emphasis on planning rather than 'serendipitous emergence' (Tiwana, 2013). The complex nature of ecosystems ensures that they are purposive rather than purposeful with a focus on the co-evolution that occurs through actor interactions (Mitleton-Kelly, 2003). Hence, it is now very important to relay the process of intermediation in relation to the way that the operating environment is evolving (Tiwana, 2013). This is where innovation intermediation scholarship and research are particularly important.

To understand how innovation ecosystems can be assisted by innovation intermediation literature, most of the literature from the review was from an innovation systems perspective. Merging intermediaries and innovation systems is due to both bodies of literature placing emphasis on knowledge generation and information dissemination amongst actors (Nilsson & Sia-Ljungström, 2013). Watkins et al (2015) ascertained through a literature review of National Innovation Systems that innovation intermediation offers valuable insights on how institutional capacity building occurs and how it may be directed at both a macro and micro level governance. Studies combined innovation intermediary and innovation systems literature in three main ways that are combinations of the pillars depicted in Figure 5.7.

Figure 5.7: Integrating Innovation Systems Functions and Intermediary Roles

The first way has been studies that looked at the roles that are exhibited by innovation intermediaries in innovation systems with integration of the Technology Innovation Systems (TIS) functions. Munthali et al (2018) aligned the innovation intermediary activities in the case studies and roles under demand articulation, matching demand and supply and innovation process management as outlined by (Klerkx & Leeuwis, 2008b). These type of studies moved past just identifying the roles of intermediaries and conducting empirical studies that expose context-specific aspects of how intermediaries work (Hakkarainen & Hyysalo, 2016; Kanda *et al.*, 2018).

Secondly, studies applied the Technology Innovation Systems functions mentioned in Chapter 3 directly to inform intermediary organisations (Gamidullaeva, 2018; Kanda, Río, Hjelm, *et al.*, 2019). This gave the resultant list of significant functions performed by innovation intermediaries in the innovation systems to include knowledge creation and dissemination, setting directions of research and development, entrepreneurial experimentation, creation of new markets, creation of legitimate entrepreneurial business environment, mobilisation of resources and development of positive externalities (Gamidullaeva, 2018).

The third way is the one that is significant to this study. This was done by the integration the Technology Innovation Systems (TIS) functions with intermediary functions to form analytical frameworks that can be used to analyse different systems. The functions-thinking from the TIS approach is relevant for the innovation intermediary literature since connections can be made between the roles of intermediaries in innovation and TIS functions (Kanda *et al.*, 2019; Lukkarinen, Berg, Salo, *et al.*, 2018; Nilsson & Sia-Ljungström, 2013). This functional approach was suggested as a step towards consensus building and clarity regarding the different types of intermediaries, and their roles in systems (Kanda *et al.*, 2019). Such frameworks were introduced mainly to address the disparities of there being a lack of substantial number of clear referral frameworks for how to analyse an innovation system (Kanda *et al.*, 2018). Guo and Guo (2013) noted that literature recognises the functions of innovation intermediaries within the innovation process but there is still a lack of systemic analyses and frameworks that address functions and roles of intermediaries from a knowledge processing perspective. There is a need to show how intermediaries learn and implement activities in an interactive way across the orgware, hardware and software[13] of the ecosystem (Stewart & Hyysalo, 2008).

Lukkarinen et al (2018) used the seven system functions identified by Bergek et al (2008) as a reference point for analysing the political strengths and weaknesses of a cleantech innovations system. They utilised the 22 intermediary functions identified in the literature by Kivimaa (2014). To operationalise their approach, they classified the intermediary functions under the innovation system function categories shown in Table 5.2.

[13] Hardware is technology in the form of new technical devices; Software are new modes of thinking and corresponding practices and learning processes; and Orgware are new institutions and socio-organisational arrangements (Stewart & Hyysalo, 2008).

Table 5.2: TIS Framework Adapted to Analyse Systems of Cleantech Deployment and Development. Source (Lukkarinen et al., 2018)

System function	**Description** (based on (Hekkert *et al.*, 2007a) and (Bergek, Hekkert, *et al.*, 2008)	**Policies and network activities** (influenced by Kivimaa and Virkamäki, 2014)	**Intermediary functions** (based on (Kivimaa, 2014)
Knowledge development and diffusion	How knowledge (e.g. scientific, technological, production, market) is developed, combined, exchanged and diffused in the system.	R & D activities and funding; knowledge exchange facilitation; informational instruments.	Knowledge gathering, processing, generation and combination; communication and dissemination of knowledge; education and training; provision of advice and training.
Influence on the direction of the search	Selection of a direction to allocate resources to; incentives to develop or adopt certain technologies or practices; visions of the future.	Targets; roadmaps; regulations; financial instruments.	Articulation of needs, expectations and requirements; strategy development; advancement of sustainability aims; policy implementation.
Entrepreneurial experimentation	Testing of new technologies, applications and markets; opportunities for learning and reduced uncertainty.	Policies to stimulate entrepreneurship; resources and platforms for experimentation; practices for risk allocation.	Creating conditions for learning by doing and using.
Market formation	Influencing demand; market creation for novel solutions throughout development stages and establishment of innovation.	Financial and regulatory instruments; public procurement policies.	Acceleration of the application and commercialisation of new technologies; prototyping and piloting; investment in new businesses.
Legitimation	Counteracting resistance to change; social acceptance and compliance with institutions.	Framing of problem and justification of policies; research-based evidence; knowledge of successful examples.	Gatekeeping and brokering; configuring and aligning interests; technology assessment and evaluation; arbitration based on neutrality and trust; accreditation and standard setting
Resource mobilisation	Financial and human resources; other complementary assets (networks and infrastructure).	R & D resources; dedicated human resources.	Creation and facilitation of new networks; managing financial resources; identification and management of human resource needs (skills); project design, management and evaluation.
Development of positive externalities	Entry of new actors into the TIS; benefits to other actors or sectors.	Complementary environmental and/ or financial benefits and knowledge.	Creating new jobs.

This method of operationalisation of TIS functions with intermediary functions was also done by Nilsson and Sia-Ljungström (2013), Watkins et al (2015) Lukkarinen et al (2018), Kanda et al (2018, 2019) and van Welie et al (2020). In Kanda et al (2019), the aim was to develop fundamentals of an approach for analysing how intermediary organisations support firms in eco-innovation[14] and potentially contribute to technological innovation system functions. They proposed a 5-step process (Figure 5.8) for utilising their approach which starts off by defining the focus of the study, identifying intermediaries in the specific context, mapping the roles that the intermediaries play in eco-innovation, assessing the identified roles and formulating the recommendations for intermediaries and the key stakeholders (Kanda *et al.*, 2019).

Such operationalisation assists ecosystems in various ways, this include supporting learning processes in innovation, focussing on the intermediary competences that spur ecosystem survival and assessing how the intermediaries can also generate value for themselves. The operationalisation for this study will be described in Chapter 7.

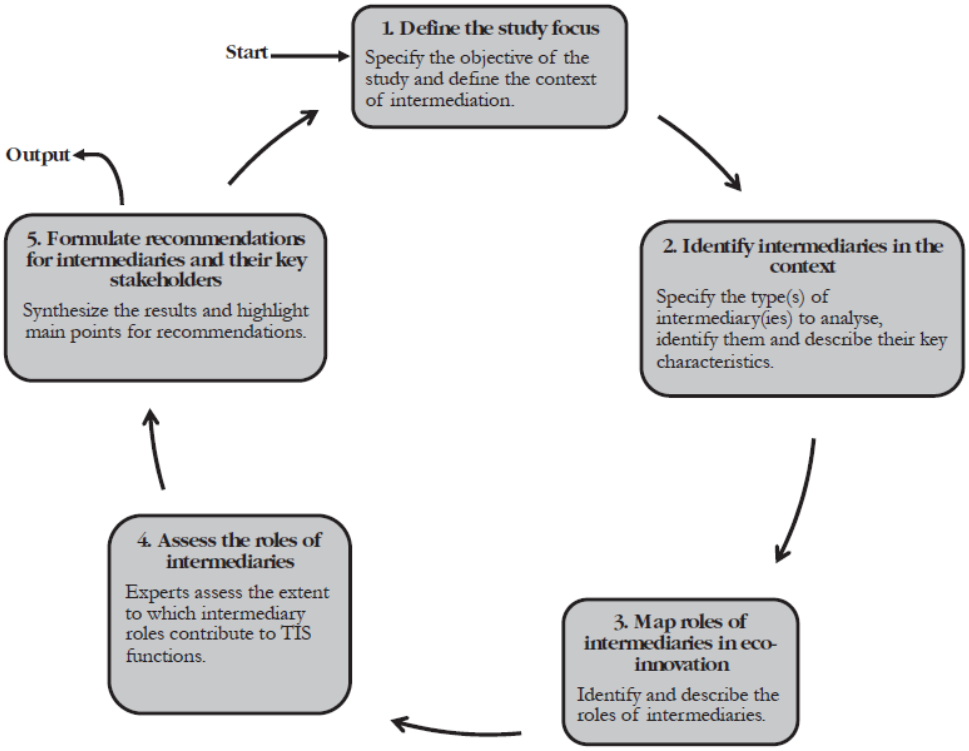

Figure 5.8: An analytical Approach to Assess the Roles of Intermediaries in Eco-innovation. Source: (Kanda et al., 2019)

5.4 Chapter Conclusion

This chapter outlined the aspect of innovation intermediaries and their importance in ecosystem research. The integration of intermediary roles and TIS functions is one that will also be utilised

14 Eco-innovation refers to the invention, commercialisation and diffusion of clean technologies that reduce carbon emissions and/or other environmentally negative impacts and thus contribute to sustainability (Polzin, von Flotow & Klerkx, 2016).

in the study. Innovation intermediation is expected to be fostered around the functions linking to the innovation ecosystems as depicted in Figure 5.9. The next chapter presents what value is and aspects of how value are created in innovation ecosystems.

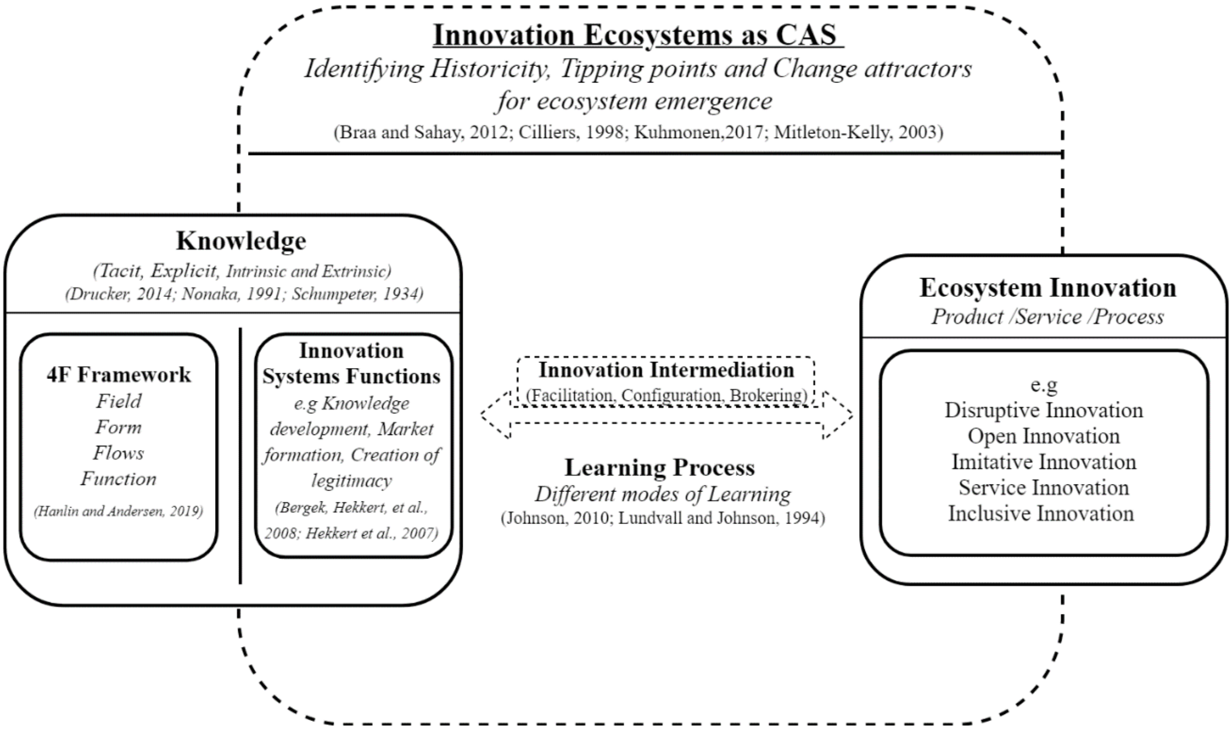

Figure 5.9: Intermediation in the Innovation Ecosystem

Chapter 6: Value Creation, Co-Creation and Innovation ecosystems

"*No one can whistle a symphony. It takes a whole orchestra to play it.*" – Halford.E. Luccock

This chapter address what value, value creation, co-creation and the aspects of value co-creation space mean to the innovation ecosystems discourse. The outline is shown in Figure 6.1.

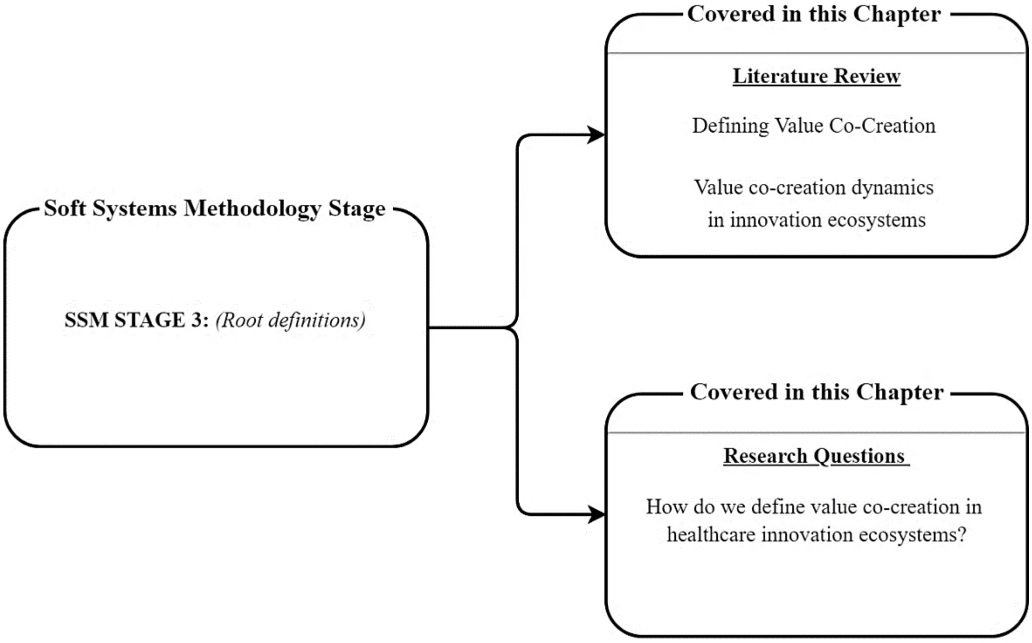

Figure 6.1: The Structure of Chapter 6 within the Context of the Soft Systems Methodology.

6.1 Value, Value Creation and Value Cocreation

The term 'value' is an idiosyncratic phenomenon that has been applied in different contexts with various qualifiers (e.g. extrinsic or intrinsic; pecuniary or non-pecuniary; tangible or intangible). Marinova, Larimo, & Nummela (2017) outlined how value has a universalist and relativist meaning associated with the usefulness and merit of something. On the other hand, Vargo et al (2008) aligned it with an improvement in a system's wellbeing linked to its ability to adapt and fit in its environment. Perceptions of value are usually guided by socially constructed norms and beliefs specific to the beneficiary and expressed through purposeful action (Vargo, Wieland, Akaka, *et al.*, 2015; Vargo *et al.*, 2016). The definition and categorisation of value has been researched extensively in the fields of economics, marketing and service science – across aspects to do with experience, usage, context, impact and inter-exchange amongst actors (Leclercq, Hammedi & Poncin, 2016). The aspects of value and how value is co-created were explained in-depth through primarily service science and marketing, in particular Service-Dominant Logic (S-DL). The two main roles in this exchange are providers that offer their services and beneficiaries that create value through integration and consumption of external resources (Lusch and Vargo, 2011).

S-DL is aligned with the processes, deeds and performances (services) enacted by one party for the benefit for another (Vargo & Lusch, 2008). This study will draw on literatures from that stream to review how value and its co-creation aspects can be deconstructed to inform the study. The more prominent categories of value from S-DL are outlined below:

- *Value-in-use* is aligned with the benefit attained in using a service. This type of value has a phenomenological perspective where value is socially constructed through experiences which leads to value actualisation acquired through usage of a product (Vargo & Lusch, 2008). It has a temporal dimension alignment where initially the firm was deemed in control of value creation and the customer is co-producer and later a co-creator of value (Vargo & Lusch, 2004, 2008). Value-in-use can be exemplified when one uses a mobile phone and the applications on the phone for different purposes.

- *Value-in-exchange* aligns with how goods produced in a process are not the ends in themselves, but value is actually in the interactive process. This is a paradigm shift of logic from tangible products to exchange of intangible, specialised skills, knowledge and processes (Vargo & Lusch, 2004). This type of value stemmed from the Goods Dominant Logic where exchange of goods and services happens between producers and consumers.

- *Value-in-impact* is a spatially and temporally dynamic component of value-in-use and value-in-exchange, which represents the co-creation and co-destruction of potential value (Ketonen-Oksi & Valkokari, 2019; Lintula, Tuunanen & Salo, 2017; Matthies, D'Amato, Berghäll, *et al.*, 2016; Vartiainen & Tuunanen, 2016). Notably in some situations, alignment of value is not always possible or desirable as value co-creation can either be negative, positive or neutral (Ketonen-Oksi & Valkokari, 2019; Pera, Occhiocupo & Clarke, 2016). Acknowledging value co-destruction is important, as value can also be co-destroyed amongst actors (Grönroos & Voima, 2013; Lintula *et al.*, 2017; Plé & Chumpitaz Cáceres, 2010). Matthies et al (2016) introduced value-in-impact as a conceptual tool for discussing the positive and negative provisioning impacts throughout the value creation process.

- *Value-in-context* relates to how value is unique in each context (Vargo & Akaka, 2012; Vargo & Lusch, 2008). This was further expanded in various ways. There was the notion of *value-in_social-context* which *"recognizes that an individual's value perceptions are, at least in part, dependent on the relative position of the individual within the wider social context"*(Edvardsson, Tronvoll & Gruber, 2011: 334). There was also *value-in-cultural-context* aligned with international marketing outlining the interactions of firms and customers in international and global exchange of knowledge (Akaka, Vargo, & Lusch, 2013). With value creation and co-creation being rooted in institutions, differing actor institutions (common in cross cultural exchanges) affect the level of successful interactions where both parties derive value (Akaka et al., 2013).

This study aligns with all these aspects of value as contextually the healthcare interventions that occurred do change according to the different actors and goals of the ecosystem and how they use technology or interact. Self-reporting tools such as online diaries where customers can participate actively in generating new ideas are an example of value-in-context.

S-DL is believed to provide a deeper and broad perspective of innovation than traditional frameworks as it encourages a look beyond dyadic exchange encounters to view value being created from an ecosystems perspective. (Vargo *et al.*, 2016). The service ecosystems perspective broadens the scope of value creation to be inclusive of actions and interactions of generic actors that are relational, reciprocal and contextual (Barile *et al.*, 2016; Vargo *et al.*, 2016).

Wenger, Trayner & De Laat (2011) associated value creation with the value that networks or communities create through social learning activities. This was done through various cycles that create value shown in Figure 6.2.

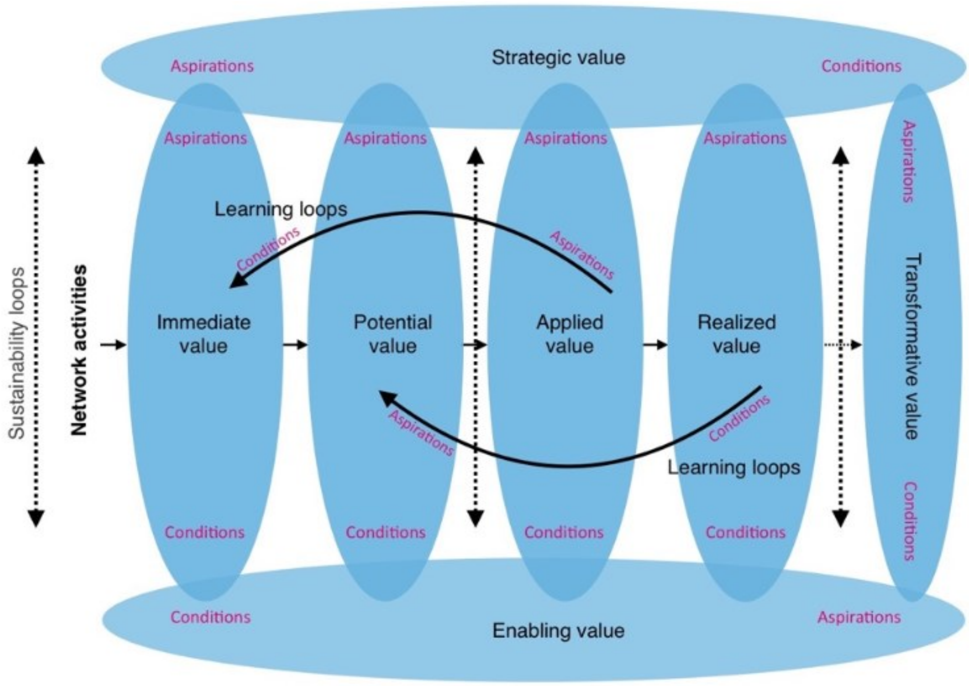

Figure 6.2: Framework for Social Learning and Value Creation

- Cycle 1 is *Immediate value* which are the activities and interactions that have value between the system members;
- Cycle 2 is *Potential value* which are the interactions, activities and knowledge capital which have been missed in cycle 1 but have potential to be realised later;
- Cycle 3 is *Applied value*: is the knowledge capital that may or may not be put into use through adapting and applying it to a specific situation;
- Cycle 4 is the *Realised value* comes from the application of new practices and tools that achieve what matters to all stakeholders enhanced by management's accountability;
- Cycle 5 is the *Transformative value* which comes about from learning which causes reconsideration of how success is defined through reframing of strategies, goals and values.

These cycles and activities include assisting each other, sharing tips, information, data, sharing experiential learning, collaborative knowledge creation. This is done from addressing who the audience is (value to whom) and perspective (long or short term) which all intersects well with the basic dimensions aligned with learning and innovation that is central in the innovation ecosystem dynamics.

6.2 Overview of Aspects of Value Co-creation

Understanding these perspectives that are used when defining value, assists in the clarification of who is involved and how value is co-created. Value co-creation was defined by Leclerq et al (2016) as a joint process where actors interact and exchange resources through a learning process. Hence, value co-creation is a process that entails the spontaneous, collaborative and dialogical interactions between people, systems, infrastructure and information and making or producing something new and a function of interaction, both materially and symbolically (De Koning, Crul & Wever, 2016; Galvagno & Dalli, 2014; Grönroos & Voima, 2013; Leclercq *et al.*, 2016; Nudurupati, Bhattacharya, Lascelles, *et al.*, 2015).

Value co-creation drastically reduces costs as trial and error is not utilised, instead consumers are asked about what they prefer and even take part in design under certain conditions (Brohman & Negi, 2015). There have been instances where customers can lead the companies astray due to improper sampling across various demographics (Christensen, Anthony & Roth, 2004; Christensen, Hall, Dillon, *et al.*, 2016). Value is co-created through the integration of existing knowledge, the development of new knowledge (and other resources), and is influenced by the context, or environment, as well as the resources of others (Vargo & Akaka, 2012: 209) through an engagement platform as shown in Figure 6.3.

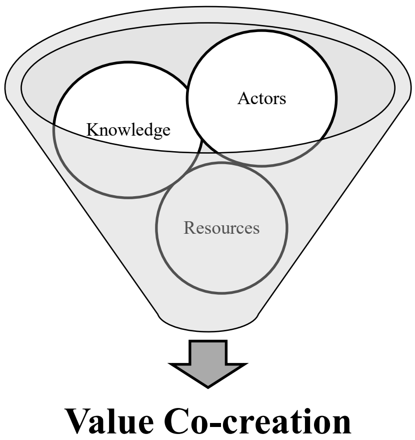

Figure 6.3: Constituents of Value Co-creation

Grönroos & Voima (2013) descriptively in the system these roles become (provider, joint, customer) through interactions which are direct or indirect) an attempt to extend how knowledge can be utilised in co-creation. This is not only in the firm-customer or user-producer relationship but also across a variety of societal organisations such as universities and government entities where co-creation depends on the availability of resources and relationships associated with the system. Actor-to-actor interactions are key rather than concentrating on producer-to-consumer only (Vargo & Lusch, 2011). Value co-creation in itself is dynamic as it is unique to a situation, context and actor interactions are constantly changing (Lusch & Nambisan, 2015; Vargo & Lusch, 2008; Vargo *et al.*, 2016). In understanding value co-creation there is need to acknowledge the shift from services (plural) or intangible outputs to service (singular) the application of knowledge and skills for the benefit of others (Vargo & Lusch, 2008). In the foundational principles of S-DL the customer is one of the key co-creators of value and value being phenomenologically, contextually and uniquely defined by the beneficiary through individual experiences (Grönroos & Voima, 2013; Vargo & Akaka, 2015; Vargo & Lusch, 2008).

Co-creation can be undertaken in five distinct ways where co-creators are invited to share, combine and select what is of value for them (De Koning *et al.*, 2016). These are co-design, community-design, personal offering, real time self-service and mass customisation. These co-creation types result depend on the varying levels of collaboration, phases in the design process and the extent of the direct value created (De Koning *et al.*, 2016). This is graphically shown in Figure 6.4.

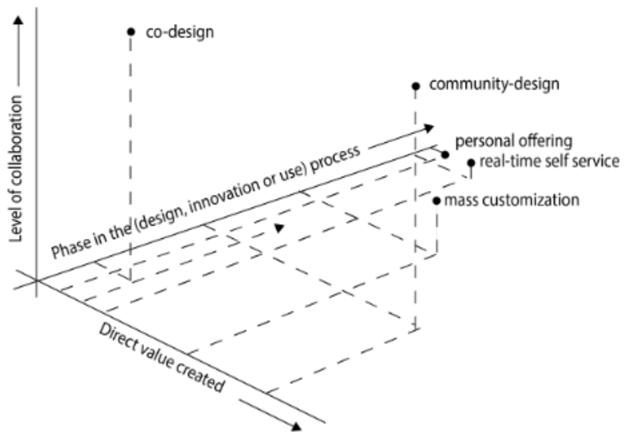

Figure 6.4: Five Types of Co-Creation (De Koning et al., 2016),

Chakraborty, Bhattacharya, & Dobrzykowski (2014) outlined components of value co-creation looking at how competencies and processes amongst actors is aligned with expectations. These competencies (knowledge and skills) can be transferred directly, through education and training in direct and indirect ways in a joint space of co-creation such as innovation ecosystems (Vargo & Lusch, 2004).

6.3 Innovation Ecosystems and Value co-creation

In order to fully apply S-DL principles to innovation ecosystems it is important to make sure that the definitions of innovation, technology and institutions are congruent. Institutions are defined as the humanly devised rules, norms and meanings that enable or constrain interactions where institutional arrangements are affected by ongoing actor interactions (Vargo *et al.*, 2015). This aligns with the innovation systems definition that was mentioned previously. Innovation is the development and adoption of new practices and for innovation to occur, institutions need to be in place (Vargo & Lusch, 2011). Technology is potentially useful knowledge that may provide solutions for new or existing problems and these can be physical and social, these competencies are at the heart of technology (Vargo *et al.*, 2015). Notably, *"the integration and reintegration (combinatorial evolution) of operant resources (useful knowledge) lie at the heart of technology"* (Vargo *et al.*, 2015: 70). Resources are in two categories; *operant resources* which are knowledge and skills that are used to provide benefit to actors such as and *operand resources* require action taken upon them to be useful e.g. goods and money (Vargo *et al.*, 2016). *Operant resources* are the underlying driver of exchange and value co-creation as knowledge and skills are a prerequisite to solving a problem (innovating). A few studies analyse value and value co-creation in terms of clearly defining the roles of actors and looking at the scope, nature and locus of value co-creation between the service provider and customers (Galvagno & Dalli, 2014; Grönroos & Voima, 2013; Leclercq *et al.*, 2016; Lintula *et al.*, 2017). When it comes to value co-creation, the importance of place cannot be over emphasised.

6.3.1 Platforms, Spaces and Value-Cocreation

Platforms are mechanisms that attract a diverse set of stakeholders motivated to solving a specific issue of common interest or investigating potential growth opportunities (Parker *et al.*, 2016). A platform provides the infrastructure and rules for a space that brings together producers and consumers (Parker *et al.*, 2016; Tiwana, 2013). Platforms have been described and classified in various ways which can be 'soft' or 'hard' platforms or technological and non-technological (Dondofema & Grobbelaar, 2020). There can be firm-centric, across-supply-chains, multi-sided, markets and industry-wide platforms (Gawer, 2009, 2014; Gawer & Cusumano, 2014; Smorodinskaya *et al.*, 2017). Thomas et al. (2014) categorised platforms according to their contextual basis which are production, innovation and transaction platforms. Nevertheless, no matter the classification, these platforms are places where value co-creation occurs. Some spaces that will be explained in this section are shown in Figure 6.5 below.

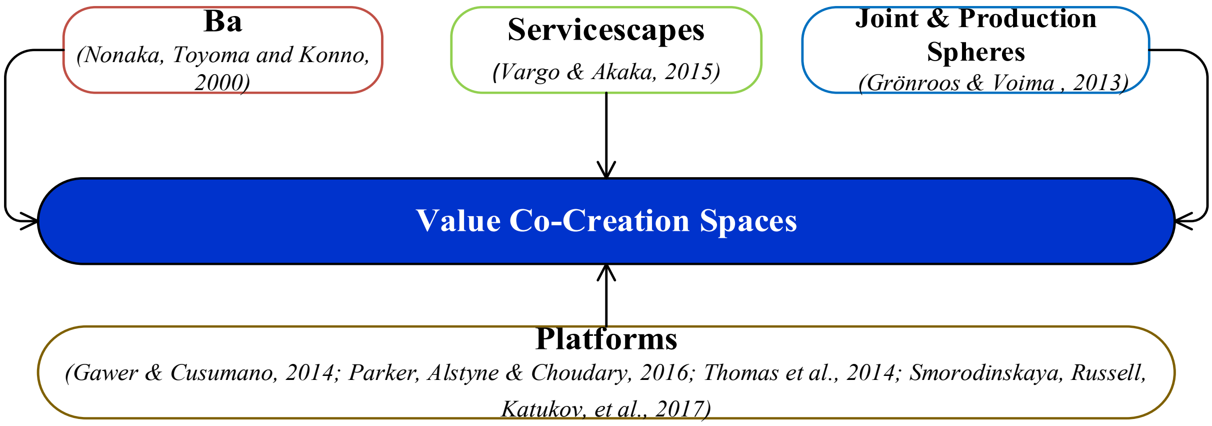

Figure 6.5: Examples of Value Co-Creation Spaces

<u>**Ba:**</u> In systems aligned with knowledge creation and assimilation, there was the concept of *Ba* that was proposed by Nonaka, Toyoma and Konno (2000). The *Ba* was described as the shared spaces and the platform for resource concentration in which knowledge is embedded. That knowledge is then acquired through the actor's experience or reflections on the experiences of other actors through a process of socialisation, externalisation, combination and internalisation (SECI). The *Ba* concept was noted to unify and encouraging the embedding of the physical, virtual and mental spaces where these spaces can all be embedded. For example, the organisational team is the *Ba* for an employee as the market environment is the *Ba* for the organisation the employee works for. Of importance was the highlight that knowledge in itself has the qualities of being intangible, boundaryless and dynamic and if it is not utilised at the

correct time in a specific place then it loses its value. Figure 6.6 depicts the relationship between Ba and the knowledge process as proposed by Nonaka et al., (2000).

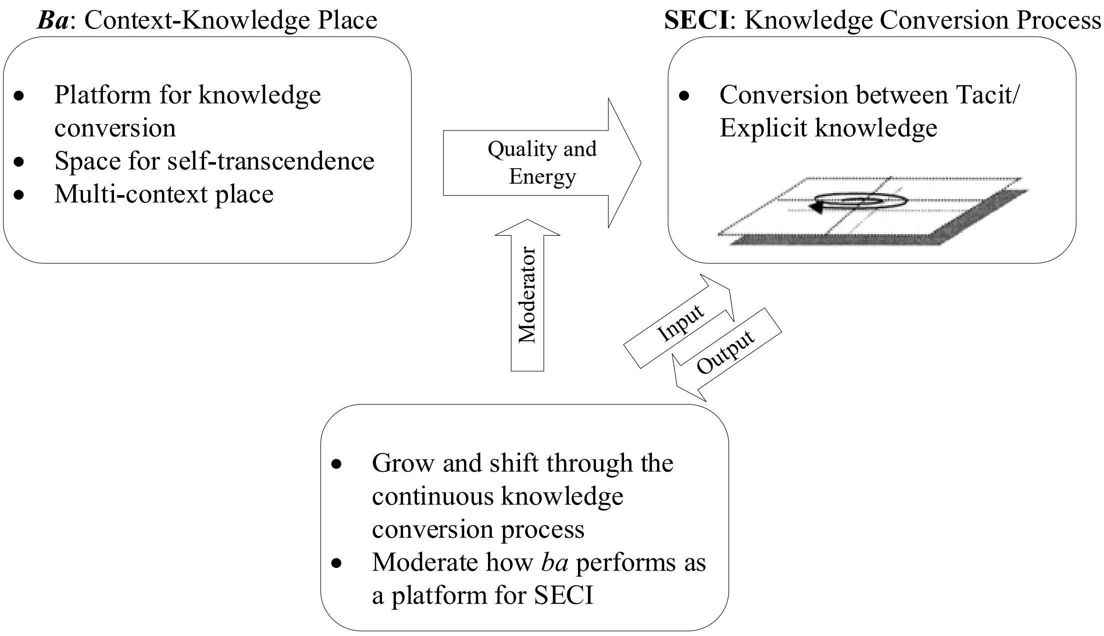

Figure 6.6: Three Elements of the Knowledge Creation Process from (Nonaka *et al.*, 2000)

Servicescapes & Spheres: In S-DL there is a notion of *servicescapes* which are all aligned with physical, social and cultural surroundings in which actor interaction and service occurs (Vargo & Akaka, 2015). For example Grönroos and Voima (2013) called the place where value co-creation and interaction occurs the joint sphere that merges the customer sphere (usage) and the provider sphere (production based potential value). Their reasoning was hypothetically assigning spheres help in analysis of the system. Grönroos and Voima (2013) through their proposition of a joint sphere of co-creation activities aided in outlining how in an innovation ecosystem, the ecosystem builder becomes more of a provider of the ecosystem actors' needs. This is because though the goal of integrating resources actors in an ecosystem, there is interaction and enactment of various practices (Barile *et al.*, 2016). An ecosystems perspective considers the direct and indirect interactions of multiple actors in value co-creation and more importantly the socio-historic contexts that value was created in aggregated interactions across micro, meso and macro levels guided by multiple institutions (Akaka, Vargo & Lusch, 2013; Vargo & Akaka, 2015).

Platforms & Ecosystems: The value co-creation process in a multi-stakeholder environment is significantly different from when in an isolated environment as the network in an ecosystem becomes itself a driver for innovative activities (Nudurupati *et al.*, 2015). These innovative activities are even more pronounced when there is mutual awareness in the ecosystem about what exactly the ecosystem is aiming to achieve (Autio & Thomas, 2014). Furthermore, depending on what the ecosystem's short term and long-term goals are, the assumption taken in this proposal is that the value created for an individual firm and the ecosystem, as a whole, varies as well. Knowledge and skills are integrated by the beneficiary of the service and that's how value is created (Vargo *et al.*, 2016).

Value co-creation is dependent on value networks which are like living organisms constantly learning, evolving and adapting to change requirements (Lusch, Vargo & Tanniru, 2010). An ecosystems view can provide a framework for studying the interaction and value creation amongst several service systems with an emphasis on the role of institutions and resource integration (Vargo & Akaka, 2012). Hence from an innovation perspective, questions are around reframing of the value network to enhance the agility, competence and speed of innovation processes and to understand dynamics around actor exchanges (Lusch *et al.*, 2010: 29). This gives the premise of the relevance of platforms in the dynamic.

The importance of the platform is it is the place where the value co-creation process occurs between the customers and providers and offers orchestration. (Kijima & Arai, 2016) provided a two-part model that distinctly differentiate between the platform and the ecosystem, shown in Figure 6.7. The value orchestration platform facilitates the value co-creating process-where different actors meet. On the other hand, the ecosystem is where the actual value co-creation takes place in four phases of interaction i.e. co-experience, co-definition, co-elevation and co-development. This model was utilised by Ketonen-Oksi and Valkokari (2019) to exemplify cases to show how innovation ecosystems can be seen as structures for value co-creation. Their focus was to add an in-depth understanding on the multi-actor processes of value co-creation (Ketonen-Oksi & Valkokari, 2019).

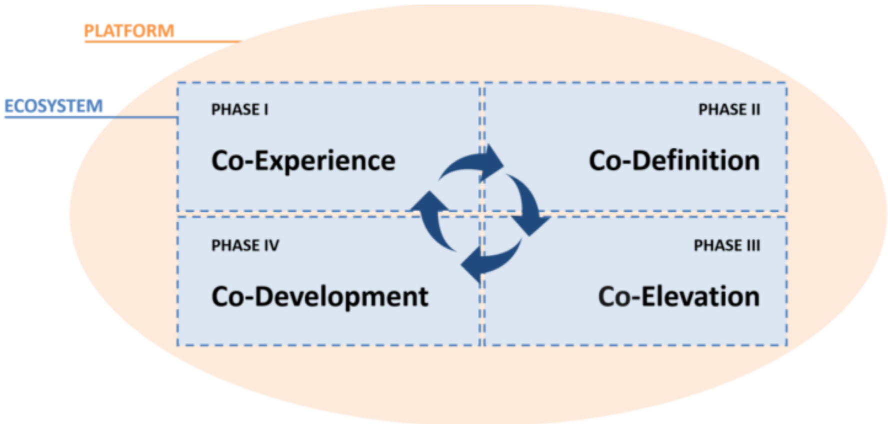

Figure 6.7: Value Co-Creation Model Proposed by (Kijima & Arai, 2016)

In the value-cocreation process of platforms and ecosystems, Autio & Thomas (2019) mapped out the structural and governance mechanisms across three distinct ecosystem types . They ascertain that there is a focal firm(s) where the overarching ecosystem value offering depends on the ability of the intermediary to orchestrate the offerings from the ecosystem actors in their various capacities. Sustainability in the ecosystem come from benefits being generated amongst all actor interactions. Nevertheless, in order for value to be co-created, providers and beneficiaries do not necessarily need to interact directly and concurrently (Autio, Thomas & Gann, 2016).

Conflict in ecosystem actors often arises depending on the personal networks and affects the roles in value creation due to the resources and relationships that are applicable in a given context (Akaka *et al.*, 2013). The challenge arises from trying to navigate the complex landscape between platform leaders and actors where coopetition occurs amongst the same actors. The social context that frames value co-creation and exchange is influenced by the diversity of resource, institutions and enactment of practices in a global and local level where value is derived (Akaka *et al.*, 2013). Companies like Android, Intel and Amazon have opened up their platforms where they have retained control of their architecture but have incentives for complementors to *innovate "on top of" the newly extended platform* (Gawer & Cusumano, 2014).

Moreover, as the technology evolves platform leaders and intermediaries need to make a business and technology decisions in a coherent manner that promotes innovation. Hence, to achieve synergies, there is a need in many complex systems industries for one firm or a small group of firms to act as a "platform leader" (Gawer & Cusumano, 2014). In value co-creation and innovation the introduction and understanding of value propositions is not enough and the new practices (innovation/solutions) have to be institutionalised (Vargo & Akaka, 2012). However, technological innovations do not necessarily mean that there is formation of a market but occurs when ecosystem actors introduce new value propositions (Akaka et al., 2017). This is congruent with the innovation systems function of market formation, in this case for technology.

6.3.2 Value Co-Creation in Healthcare

Porter (2010) defined value in healthcare as health outcomes related to the relative costs of patient care and efficiency. In healthcare, value cannot only be aligned with patients as there are many actors in the ecosystem. All these actors have a primary goal to create value for themselves but more so for the patients through participating in strategic plans and SDG oriented initiatives which inadvertently benefits the patients. In describing value, the locus is important since it is not a linear process but it is created in different spatial and temporal settings (Grönroos & Voima, 2013). Value in healthcare has been aligned with patient-centric care that integrates patient engagement, participation and involvement in service delivery activities (Hardyman, Daunt & Kitchener, 2015; Vargo & Lusch, 2008). Taking the generic definition of value co-creation being around the customer or beneficiary, the customer in this case has been generically outlined as the patients, where the creation of value for the patients should determine the rewards for all the actors in the system (Hardyman *et al.*, 2015). However, the definition of the customer depends of the level of the collaborative design as Health ministries, backend developers, data entry clerks, doctors and nurses can all be customers of one innovation process or another.

Hardyman et al. (2015) ascertain that looking at the nature of interactions at a micro-level in the healthcare sector enables exploration of how 'value' is created and experienced in such interactions. This is an area that has been foundational in understanding healthcare ecosystem value co-creation; however, looking at other levels of the ecosystem is important. There is a need to understand how co-creation occurs through various interactions at the meso, micro, macro levels. Activities of co-creation in healthcare include combining complementary therapies, collating information and co-learning. The reasoning of understanding other actors in the ecosystem goes further beyond only patient and firm interactions and includes firm to firm interactions as well (Beirão, Patrício & Fisk, 2017). In healthcare, this has arisen more from use of technology and places of creation, co-creation and capturing of value referred to as platforms (Parker *et al.*, 2016).

Important dynamics aligned with value co-creation are to investigate what tools are used for engagement of individuals, the motivations and nature of engagement amongst actors as well as the management of the actors across the value co-creation process (Leclercq *et al.*, 2016). In healthcare platforms this usually centres around patients. However, ecosystems have different levels and different co-creators. In this study the users of the platforms in the case studies were aligned with the ecosystem level of the selected cases. With MAMA and MomConnect it is the patients, doctors and nurses who contribute to the data that is input into the system. For DHIS2 this shifted from the patients to the in-country implementers of the DHIS2 and how they can effectively co-create with the health ministry.

6.4 Chapter Conclusion

This chapter outlined how value and value co-creation thrives in joint spaces that revolve around knowledge and learning. This brings to full circle the literature base that forms the conceptual framework for this study. The important theoretical aspects that are considered in the framework will be collectively described in the next section.

Chapter 7: Towards a Framework to Explain Ecosystem Evolution and Emergence

"The acknowledgement of complexity, however, certainly does not lead to the conclusion that anything goes." — Paul Cilliers

This chapter presents the conceptual framework that integrates various aspects that have been highlighted in the literature review. The framework addresses the 4th stage of the SSM methodology which is on a systems thinking level, and an outline of the guideline where it fits in the process is shown in Figure 7.1.

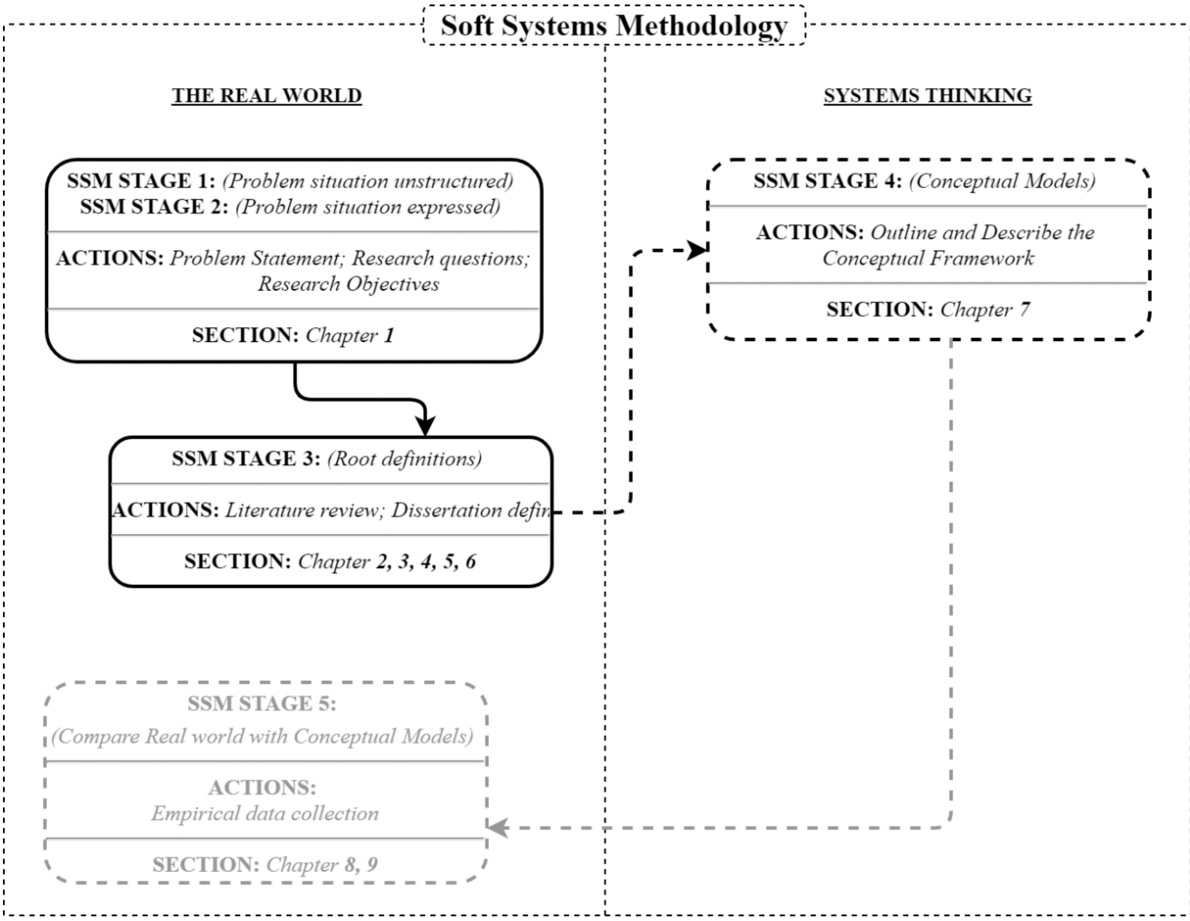

Figure 7.1: SSM Guidance in Framework formulation

7.1 Conceptual Framework features

A conceptual framework "*explains, either graphically or in narrative form, the main things to be studied—the key factors, variables, or constructs—and the presumed relationships among them. Frameworks can be simple or elaborate, common sensical or theory driven, descriptive or causal"* (Miles *et al.*, 2014: 20). It is a guide for answering the research questions that are presented in the study and an argument for the relevance of the study (Ravitch & Riggan, 2016). Conceptual frameworks are the researcher's map of what is being investigated. The framework forces the researcher to be selective and ideally improves and becomes more differentiated and integrated as the study progresses and the researcher's knowledge deepens (Miles *et al.*, 2014).

It is something that is constructed from ideas that are borrowed from elsewhere (Maxwell, 2013). Nevertheless, the structure and overall coherence is built through understanding current phenomena and not something that readily exists.

In constructing a conceptual framework the purpose is not only to be descriptive, but also critical, making clear the contributions of the framework (Maxwell, 2013). The researcher has the role of a bricoleur[15], who spontaneously adapts to the situation and creatively employs the available tools and materials to come up with unique solutions to a problem (Maxwell, 2013). Conceptual frameworks exhibit a few of the following key features:

- *Integrative:* a framework is not just a collection of concepts, there must be some degree of coherence among them (Miles *et al.*, 2014).
- *Evolving:* conceptual frameworks are not static (Maxwell, 2013; Ravitch & Riggan, 2016). The framework is expected to evolve as the study progresses (Miles *et al.*, 2014).
- *Constructability:* framework development utilises multi-disciplinary approaches (Jabareen, 2009)
- *Interpretative capacity*: a framework presents hard facts but more soft interpretation of intentions and an interpretative approach to social reality (Jabareen, 2009). It represents an integrated understanding of issues, within a given field of study, which enables the researcher to address a specific research problem.
- *Indeterministic:* a conceptual framework does not enable one to predict exactly the outcome of some or other set of activities due to the freedom of human behaviour. However it can aid in improving the likelihood of certain outcomes, which, in this case relates to increasing the likelihood of fostering growth (Jabareen, 2009).
- *Understanding*: conceptual frameworks help to understand phenomena rather than predict it (Jabareen, 2009).
- *Capacity for modification*: conceptual frameworks can be reconceptualised and modified according to the evolution of the question or as a result of new data and publications that were not available when the framework was first developed (Ravitch & Riggan, 2016).

The conceptual framework presents an argument about the topic that is being studied and shows why the means proposed to do so is appropriate and rigorous through sequenced, logical propositions (Ravitch & Riggan, 2016). Beside the generic requirements of a conceptual framework, there needs to be design requirements that align with the context of the study. Consideration was made about the requirements which were formulated throughout the dissertation through substantiation of why the proposed framework is necessary. The requirements emerged out of Chapters 1 to 6 to support how an innovation intermediary can assist the value co-creation process of an innovation ecosystem.

To guide the framework design process in this dissertation, the author drew on the work of Van Aken and Berends (2018) who categorised the requirements according to:

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[15] Bricoleur refers to the deliberate mixing of qualitative quantitative methods and ways of thinking in order to address a specific issue or problem. It has been used within academic qualitative research to describe a pragmatic and eclectic approach to qualitative research - https://www.aqr.org.uk/glossary/bricolage

1. *Functional requirements (FR)*: which are the core specifications usually in terms of the performance or demands on the designed framework.
2. *User requirements (UR)*: are specific requirements from the view of the user that are with regards to the use of the framework.
3. *Design requirements (DR)*: this addresses the limits of the design and elements not covered in the framework which may be negotiable.
4. *Boundary conditions (BC)*: these are the framework requirements that must be met unconditionally and may not be altered e.g. a code of conduct or ethical procedure.
5. *Attention points (AP)*: these are design specifications that should be noted but not necessarily need to be met and are not design restrictions.

These requirements are expanded for this dissertation in Table 7.1.

Table 7.1: Outline of Framework Requirements from Literature

Framework Requirement	ID	Description and reference in dissertation
Functional Requirements	FR1	The framework should enable efficient resource allocation *(Chapter 1.2)*
	FR2	The framework should encourage and enable the joint design of sustainable (healthcare) innovation ecosystems *(Chapter 1.2)*
	FR3	The framework should identify how actors collaborate *(Chapter 1.2)*
	FR4	The framework should provide a basis for consensus building and clarity between intermediaries and their roles in an innovation ecosystem *(Chapter 5.7)*
	FR5	The framework should go beyond just metaphoric symbolisms *(Chapter 3.1)*
	FR6	The framework should provide a basis to include intangible actor interactions and knowledge flows *(Chapter 4.4)*
Design Requirements	DR1	The framework should embrace complexity in the design process *(Chapter 1.2)*
	DR2	The framework should have a multidisciplinary approach guidance *(Chapter 2.2)* and the non-linear relationships and states of the ecosystems *(Chapter 3.1)*
	DR3	The framework should address the theoretical underpinnings that address the different relational dynamics that occur amongst the ecosystem actors *(Chapter 1.6)*
	DR4	The framework should assist in understanding how the ecosystem actors interact, create value and co-evolve *(Chapter3.1)*
	DR5	The framework should acknowledge the evolution between these elements *(Chapter 3.1)*
	DR6	The framework should use a structuralist approach to conceptualise the ecosystem construct *(Chapter 3.1, 3.6, 4.2)*
	DR7	The framework should clearly outline the roles and functions of the innovation intermediary *(Chapter 4.2)*
	DR8	The framework should provide guidelines of how the ecosystem can learn from its past or past projects done in other ecosystems *(Chapter 4.4)*
	DR9	The framework should have a sound theoretical base *(Chapter 3.1)*
	DR10	The framework should provide a method for extracting and identifying key activities that affect the relational behaviour amongst ecosystem actors *(Chapter 2.2 and Chapter 4.4)*
	DR11	The framework should map the ecosystem value co-creation process flows *(Chapter 2.2)*

Framework Requirement	ID	Description and reference in dissertation
User Requirements	UR1	The framework assists the user to carry out some form of ecosystem management *(Chapter 1.2)*
	UR2	The framework must assist management to proactively be aware of the dynamics occurring in the ecosystem *(Chapter 4.2)*
	UR3	The framework must assist management to check the capabilities of the intermediary firm *(Chapter 5.2)*
Action Points	AP1	The framework should address governance issues *(Chapter 1.6)*
	AP2	The framework should consider the use of technology in ecosystem management *(Chapter 3.1)*
	AP3	The framework does not need to provide a predictive way of what happens when particular activities and actions occur in the ecosystem *(Chapter 1.3: Chapter 4.4)*
	AP4	The framework shows when value has been successfully appropriated *(Chapter 3.1)*
Boundary Conditions	BC1	The framework should assist ecosystem actors that have shared institutional logics with a set of common rules of how to participate in the ecosystem *(Chapter 4.3)*
	BC2	The framework does not aim to differentiate the ecosystems construct from other systems of innovation constructs (Chapter 3.1)
	BC3	The framework should be clear about which aspects, artefacts and dynamics are being investigated *(Chapter 4.4)*
	BC4	The framework provides frequency of interactions between specific ecosystem actors as measure of the nature and quality of ecosystem relationships *(Chapter 2.2 and Chapter 3.1)*

Utilisation of the requirements mentioned above as guide in addressing framework requirements is not new. Examples of studies that were based on an earlier edition of the Van Aken and Berends' book are Brockmöller's (2008) protocol design of a study about knowledge sharing in expert-apprentice relations by; Weber's (2011) protocol for innovating with end-users; a study by Krause & Schutte (2015) who proposed an open innovation approach for Small and Medium Enterprises and a framework for the use of antifragility in a SME context by Kennon (2017). Meeting the types of requirements outlined in this section is important as the framework needs to be appropriate and rigorous. This includes encompassing the study goals, context and questions. The verification is undertaken in section 7.5 of this chapter.

The framework was conceptualised from the literature that has been presented and the reasoning behind each of the elements will be outlined in the next section.

7.2 Concept Map of Theory used in the Framework

A concept map gives the visual display of what is going on (Novak, 1998) cited in (Daley, 2004). It was originally developed by Joseph Novak. When it comes to depicting theory, it offers clarity on what is going on with the phenomenon under study and how the selected theory addresses various aspects of the study (Miles *et al.*, 2014; Ravitch & Riggan, 2016). Concept maps are used to structure and organise ideas, show relationships and visualise the overall concept.[16] Diagrams are more explicit than lists about sequences, hence they can be sources of

[16] https://miro.com/blog/concept-map/

creative solutions (Ravitch & Riggan, 2016). Moreover, with frameworks being best depicted graphically rather than just described as text – getting the framework on a single page requires specificity and mapping of likely interrelationships using linking words.

A concept map can be used in various ways which include framing a research project, reducing qualitative data, analysing themes and interconnections in a study and presenting findings (Daley, 2004). Hence due to the complex nature of the study, starting off with a concept map that shows the logical flow of the selected theory in the dissertation before explaining the theory is useful. The map is built on assumptions; the four key assumptions in this study are:

1. Innovation ecosystems need some form of lead actor/institution that assist with proactively assisting the innovation process of individual actors and the ecosystem.
2. Innovation intermediary roles and functions need to be outlined according to the ecosystem needs and growth.
3. There is a lack of properly outlined processes and activities that pinpoint the cause of ecosystem emergence or dissolution.
4. Actor interactions hold key information which aids ecosystem evolution and identifies key activities (leverage points) which steer the ecosystem into different directions.

Figure 7.2 provides the concept map of the study to help merge all the theoretical aspects that were highlighted and chosen from the literature review undertaken in chapters 2 to 6 which are the building blocks of the conceptual framework. Table 7.2 then goes on to contextualise the aspects highlighted in the map to show how the sub-research questions were answered. The main point of departure are the fundamentals that are essential for building a conceptual framework to ensure that what is formulated next has a point of reference and some form of guidance. The cumulative outline of how Soft Systems Methodology (SSM) is used as a guide for the study is outlined. The description of the subsystems of the framework will be clarified in the rest of the chapter from section 7.3.

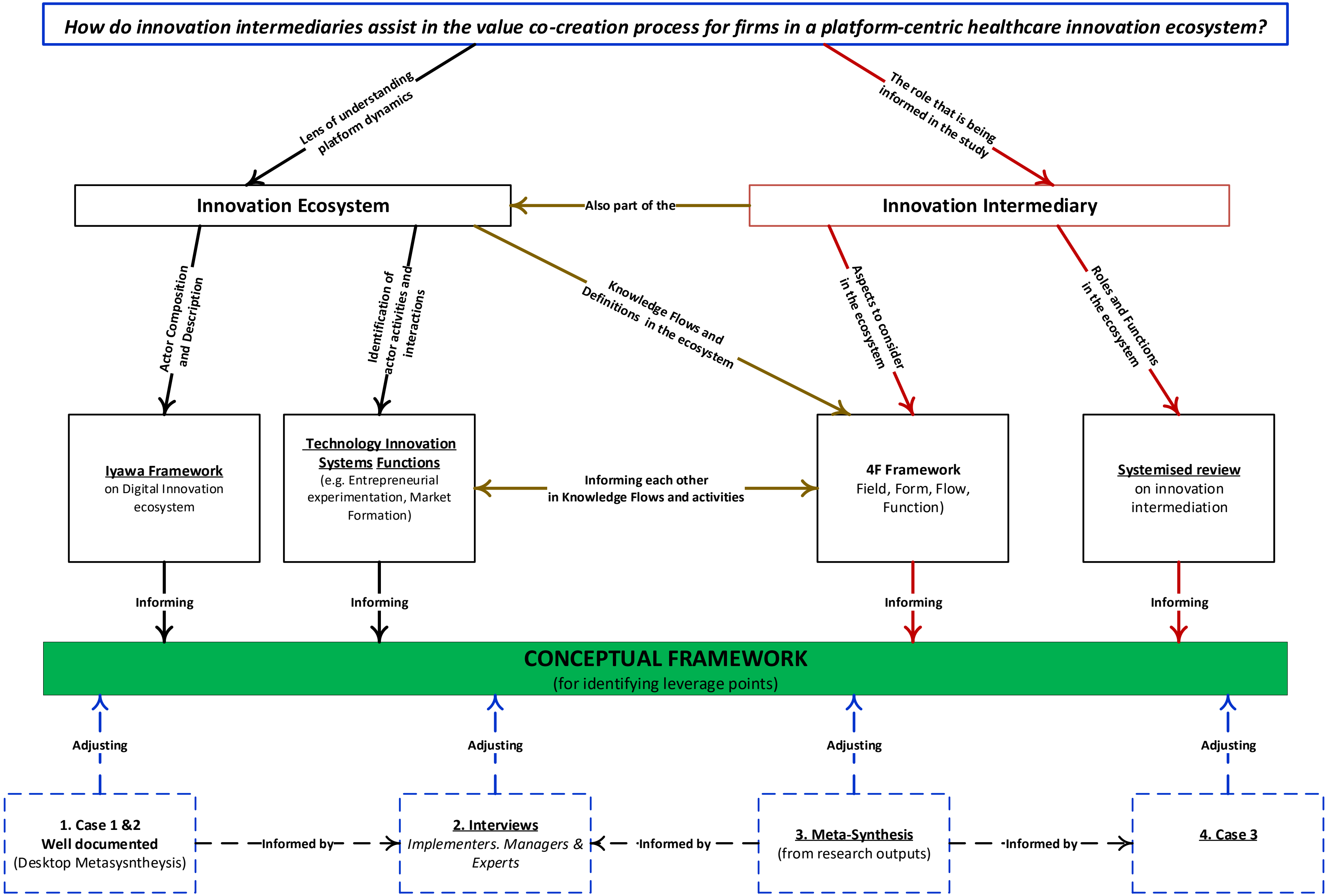

Figure 7.2: Concept Map of Study Theory

A starting point is to ensure that all the study research questions that were asked at the beginning of the study are adequately addressed. This is done by updating all the aspects outlined in Chapter 1 with the referral literature by the deconstruction of the main research question in Table 7.2.

Table 7.2: Updated Alignment of Literature with Framework

Section of Research question	Research Domain	Sub research question	Theoretical basis
*How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric healthcare **innovation ecosystem**?*	Innovation Ecosystems ***(Chapter 3)***	• How do we define innovation ecosystems?	• An interdependent network of multi-later self-interested actors who interact in order for a focal value proposition to materialise (Adner, 2017; Bogers *et al.*, 2019)
		• What are the origins of this idea and how has it evolved over time?	• Analysis of literature on Innovation ecosystems, **identification of research gaps and synthesis of innovation ecosystem research gaps**
		• What are healthcare innovation ecosystems?	• Basis of actor **identification of ecosystem actors** (Iyawa, 2017)
		• How is it different from other systems perspectives of innovation?	• Comparison with **Technology Innovation Systems (TIS)** • **Health Systems** - 4F Framework
*How do **innovation intermediaries assist in the value co-**creation process for firms in a platform-centric healthcare innovation ecosystem?*	Complex Adaptive Systems ***(Chapter 4)***	• What can the innovation intermediary do in an innovation ecosystem?	• Innovation Ecosystems as CAS • **History/Events, Attractors, Leverage points** as sources of ecosystem sustainability
*How do **innovation intermediaries** assist in the value co-creation process for firms in a platform-centric healthcare innovation ecosystem?*	Innovation Intermediaries ***(Chapter 5)***	• What is the definition of an innovation intermediary? • What are the characteristics of an Innovation Intermediary? • Which intermediary roles are important to the firms to promote value co-creation in the ecosystem? • How do they align with innovation ecosystem dynamics?	• Systemised Literature review of Innovation Intermediaries • Identification of Intermediary functions and roles • **Identification of merging of TIS functions and Innovation intermediary roles**
*How do innovation intermediaries assist in the **value co-creation** process for firms in a platform-centric healthcare innovation ecosystem?*	Value Co-Creation ***(Chapter 6)***	• How do we define value co-creation in healthcare innovation ecosystems? • What are the main dynamics and barriers to value co-creation in healthcare ecosystems?	• Service Dominant Logic Stream ○ Value and Value Co-Creation dynamics

How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric *healthcare innovation ecosystem?*	Platforms in healthcare ***(Chapter 6)***	• How do innovation ecosystems emerge and evolve around platforms? • How do innovation intermediaries assist in the evolution, emergence and sustainability of the Innovation ecosystem?	• Platform characteristics that contribute to sustainability: • Architectural openness (Technology, activity, value) • Leverage (innovation, production, transaction)
How do innovation intermediaries assist in the value co-creation process for firms in a platform-centric healthcare innovation ecosystem?	Conceptual Framework ***(Chapter 7)***	• What are the requirements for designing a framework to explain the emergence of the healthcare innovation ecosystem?	• Integration of identified necessary aspects • **TIS-**descriptive functions • DHIS2 research and documentation review • **CAS** attractors and leverage points as indicators of learning in the innovation ecosystem

7.3 Development of the Ecosystem Emergence and Evolution Framework

The framework is on two operational levels, these are structural and functional. Structurally the purpose of the ecosystem, actors and boundaries of the ecosystem are essential to understand. The structure determines the functional perspective that relates to the innovation intermediary perspective, change attractors and the actor interactions. The overarching framework is shown in Figure 7.3.

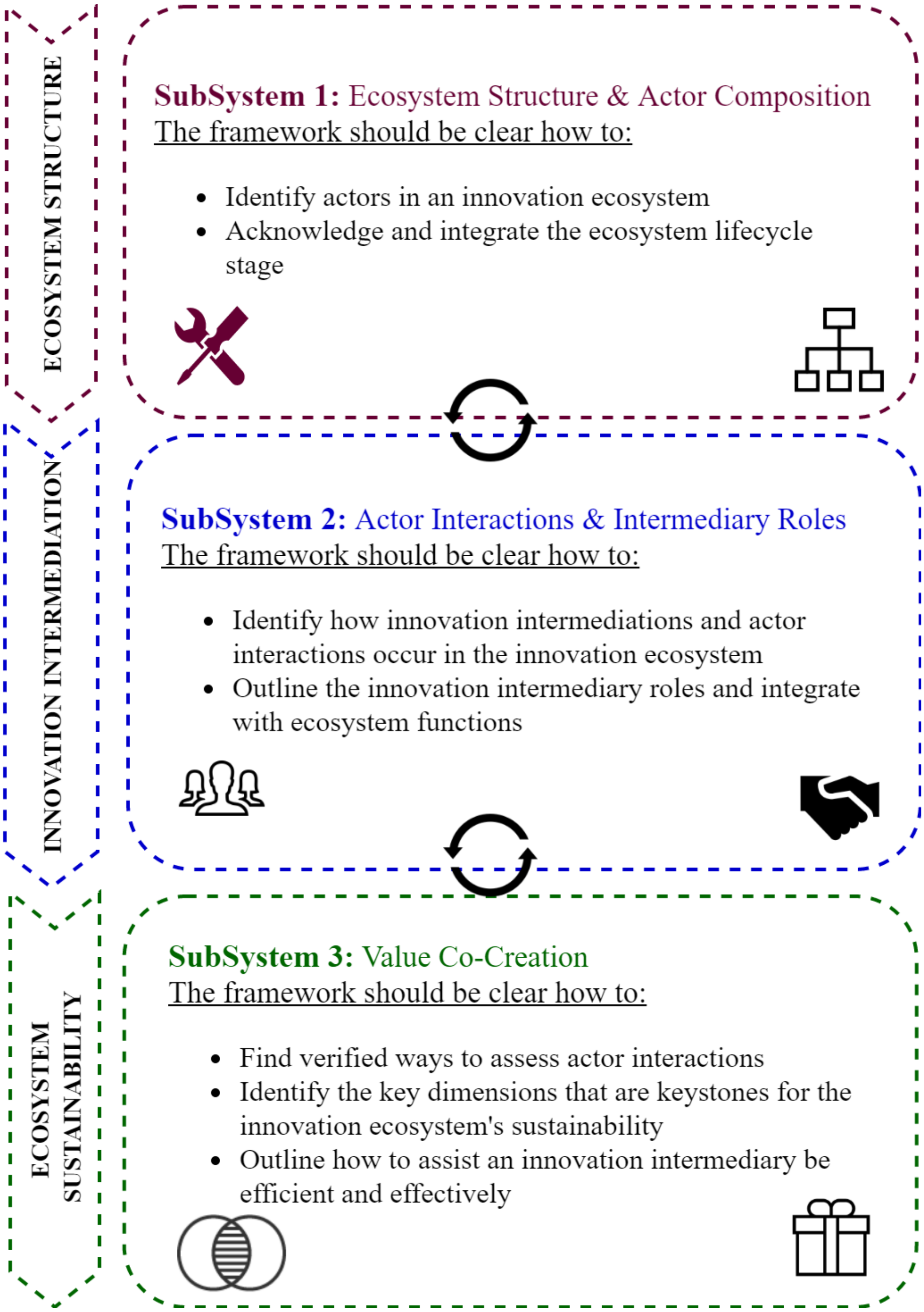

Figure 7.3: The Overarching Ecosystem Evolution Framework Blocks

The purposeful activity systems are described below integrating what has come from the literature review. They are colour coded to align to the respective subsystems and clarity of how each aspect answers the aspects that the framework aims to address.

7.3.1 Structural Level: Innovation Ecosystem Purpose and Arrangement

Subsystem 1: The relevance of having descriptive elements of the innovation ecosystem in the framework is twofold. Firstly, in the innovation ecosystems discourse there is contention when it comes to description of what an innovation ecosystem entails; thus, by being clear where the standpoint originates for the study, it serves as a point of clarity. Secondly, the innovation ecosystems construct can be classified as a complex adaptive system (Roundy *et al.*, 2018; Valkokari *et al.*, 2017). With complex adaptive systems, current behaviour is explained from the historical choices available, actors involved and actions undertaken (Cilliers, 1998; Mitleton-Kelly, 2003). Thus, having a longitudinal description according to the constituency of the innovation ecosystem from an actor perspective also aids in understanding the ecosystem. To fully describe this structural level the following questions formulated from SSM should be answered:

1. What is the purpose of the ecosystem?
2. Who are the actors?
3. What competencies are currently in the ecosystem and required to meet the ecosystem purpose?
4. What are the boundaries?
5. What lifecycle stage is the ecosystem in?

The structural subsystem components are outlined in the sections below:

7.3.1.1 Aim of the Innovation Ecosystem

This outlines the purpose of the ecosystem, the reason the ecosystem exists, the ultimate goal of the ecosystem as well as future planned initiatives (Adner, 2006, 2017; Hanlin & Andersen, 2019). In general, this is ideally a clear mandate which is set out from the beginning as the ecosystem is made up from the onset of the ecosystem. The fundamental purpose of the ecosystem defines the boundaries as well as main mandates of the ecosystem (Adner, 2017). Nevertheless, because other aspects of the ecosystem cause continual realignment of what exactly the function of the ecosystem is at a moment, the innovation intermediary has to continually align the value co-creation activities of the ecosystem with the user needs and stage of ecosystem growth.

7.3.1.2 Identification of Ecosystem Actors

These are the *forms* of the ecosystem aligned with system actors identification, interaction and collaboration dynamics (Hanlin & Andersen, 2019). In this framework, not only is it necessary to identify who are the crucial ecosystem actors and their capabilities but, moreover, to identify previous actors of such projects in order to make sure that tacit knowledge is not lost.

For the intermediary these are in 2 distinct categories; actors that are in the current ecosystem and actors that are strategic to add or remove from the ecosystem. In a platform-centric ecosystem these actors from a digital health innovation ecosystems perspective have been outlined by (Iyawa *et al.*, 2016) and are outlined in

Table 7.3 with examples. For this framework it is the identification of the actors, such as the community, technology digital species, biological species and economic species that are of importance, other aspects have been covered in various other subsystems of the framework. The rest of the components have been addressed in different parts of the framework described below, and the author added examples of the type of healthcare organisation aligned with each component.

Table 7.3: Healthcare Innovation Ecosystem Components, edited from (Iyawa et al., 2016)

Components of Healthcare Innovation Ecosystems		
Component	**Description**	**Example**
Community	Entire species available within the healthcare ecosystem environment	Regions, Provinces, Countries, Districts
Content	Information or services which are of use to the species available within the innovation ecosystem.	Personal health records, Disease statistics, Provincial records
Practice	Policies and regulations for operation in the ecosystem	Regulations: Abuja Declarations (2005), Ouagadougou declaration of primary healthcare;
Technology Digital species	Hardware and software responsible for the information interchange ; health systems and health information resources	Mobile and Web applications, APIs, Storage and Collaboration portals , Wearable devices
Biological species	Users/ people in the ecosystem	Patients , Doctors, Nurses, District health Officers, Information officers, Government officials, Developers
Economic species	Companies and Institutions	Ministry of Health, Provincial Governments, Hospitals, Research institutions, TTOs
Security	Protection of resources and species in the ecosystem	Blockchain, Biometric, RFID, NFD
Trust	Trust between actors in the ecosystem to achieve same goals	Partnerships and Collaborations, MOUs
Strategy	Alignment of strategy and goals of the ecosystem	Health 2020/2030 vision, Sustainable Development Goals, The Africa Health Strategy (2017-2015)
Operational environment	Where the biological, economic and digital species interact.	Oncology Industry, Weightloss industry, Maternal Health etc

7.3.1.3 Competencies in and around the Innovation Ecosystem

This is the *field* of the ecosystem. It aligns with 3 main paradigms aligned with institutions and funding organisations. The reason these are important is aligned with how interventions especially in healthcare tend to be influenced by the regulatory environment as well as the funding organisation. In developing countries this is a dynamic that has seen technology being developed externally and implemented by non-government employees. Hence a 3rd paradigm exists in terms of the geographic context which is important to consider. Context plays a key role especially when aligned with the processes that have to do with technology-centric systems of innovation and value co-creation (Markard *et al.*, 2015). This is particularly important especially in service delivery initiatives; it assists in addressing how they are deployed and maintained for sustainability. Understanding such dynamics contextualises the cases which highly influences the resulting analysis.

7.3.1.4 Dimensionality (Boundary Spanning) of the Innovation Ecosystem

This component outlines the life-cycle stage that the ecosystem under review is in. The stages are birth, expansion, leadership/authorities and self-renewal (Moore, 1993; Rong *et al.*, 2013). Due to different dynamics of the life-cycle stages of the innovation ecosystem this affects the types of actors in the ecosystem, the resource needs and other functional requirements in order to adequately address the purpose, goals and aims of the ecosystem as well as the value that is appropriated and created (Moore, 1993; Rong *et al.*, 2013). At every stage of ecosystem growth overall mapping of these arrangements through an event-driven process of analysing the fields, forms, flows and function of the ecosystem by asking **What-was** (historical projects undertaken under the same intervention), **What-is** (current state) **and What should be** (strategic goals of the ecosystem) is important. Once the stage of growth of the ecosystem is ascertained, then the main questions become outlined as shown in Figure 7.4.

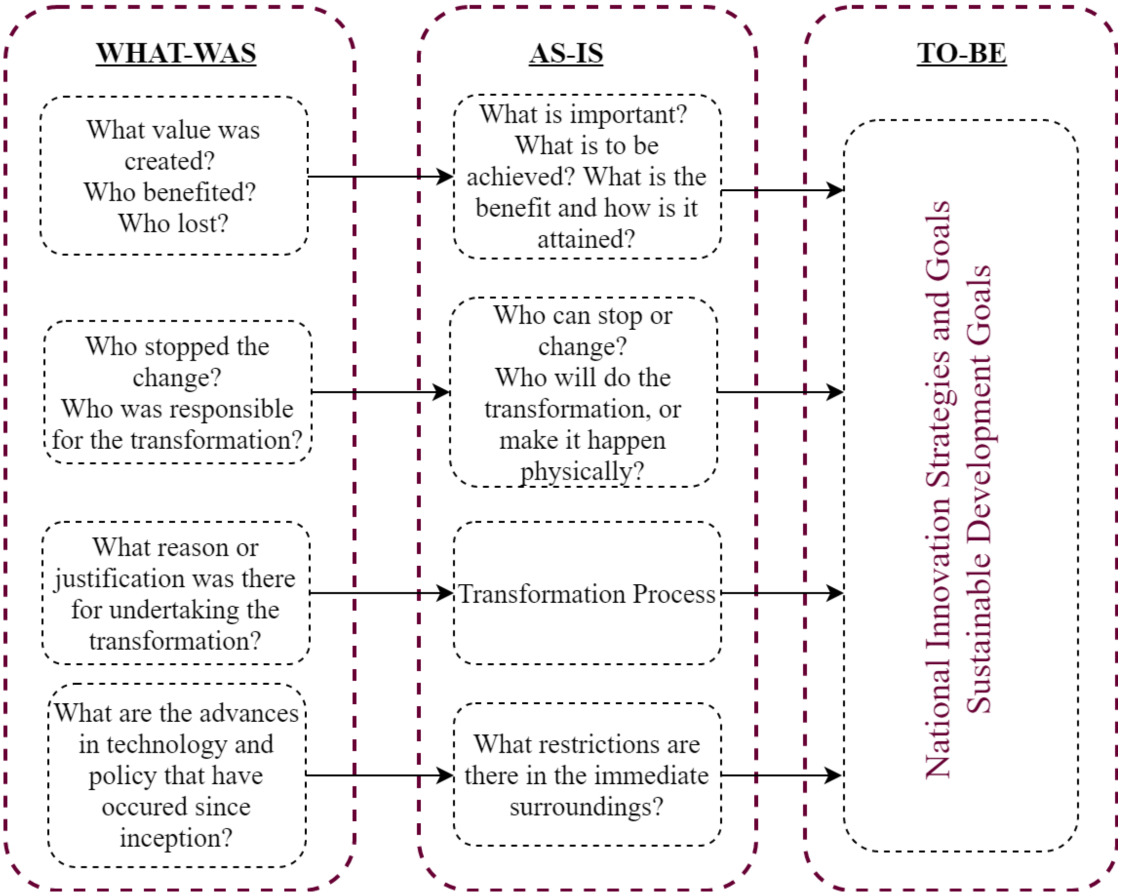

Figure 7.4: Ecosystem Evolution Dimensionality

What-was: in the process of forgetting knowledge, this aligns to looking at other innovative solutions that might have tried to address or are addressing the current concern of the innovation ecosystem. Taking it to a contextual level, when it comes to healthcare related initiatives, there is a tendency to have a lot of silo projects which address the same problem. In this case, the government (Ministry of Health) or the hospitals that are central in the implementation of such solutions are good starting points for knowledge repositories on past deployments and trials. To note is that knowledge deteriorates when not utilised and it has to be maintained through remembering, hence it is one of the main priorities of an innovation intermediary that such does not occur in an innovation ecosystem (Johnson, 2010). **What-is and What should be**: This is the current state of the ecosystem aligned with the overall goal of the innovation ecosystem. In this study an outline of what the current state is and what is should be is guided by using SSM.

7.3.1.5 Diagrammatic Outline of Subsystem 1

Cumulatively, Subsystem 1 filled in from the narrative and explanations given above is shown in Figure 7.5.

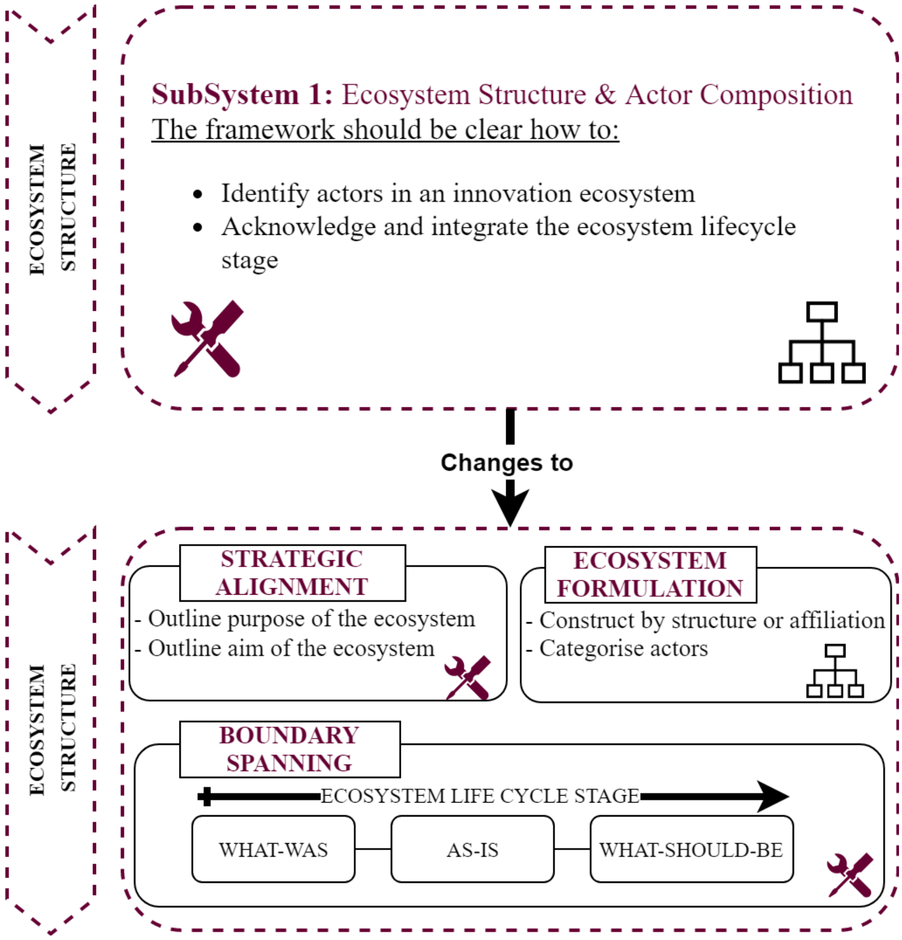

Figure 7.5: Subsystem 1 Framework Configuration

7.3.2 Functional and Activity Level

In this level of the framework it deals with the actor interactions and directly addresses how value is created in the ecosystem.

7.3.2.1 Subsystem 2-Innovation Intermediary Roles

In the framework the innovation intermediary is an ecosystem actor. On top of the roles that are of importance to this study are the characteristics that are required from the intermediary. When it comes to technology-centric innovation ecosystems, especially in regulated industries such as healthcare this is of paramount importance.

i. *Roles and Activities:* from the literature review undertaken on innovation intermediation and the roles of intermediaries in ecosystems, core aspects aligned with innovation ecosystems. The functions of the innovation intermediary can range from a wide section of roles mainly around facilitation, brokering and configuring summarised in Figure 7.6 (Bessant & Rush, 1995; Hakkarainen & Hyysalo, 2016; Howells, 2006).

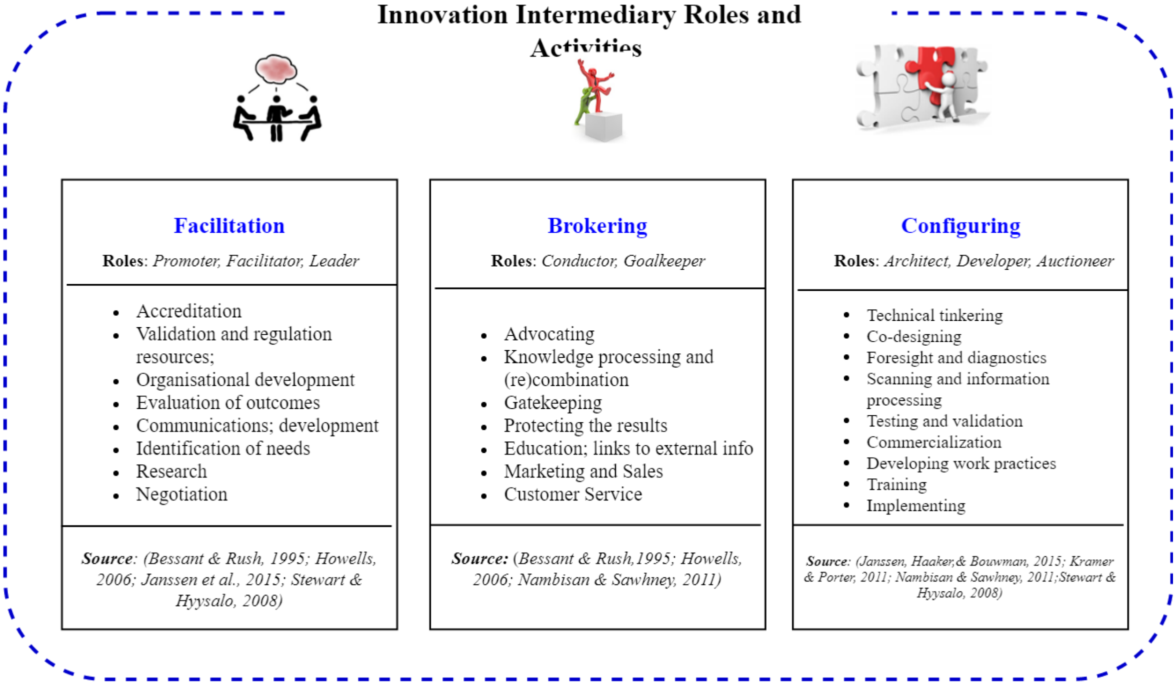

Figure 7.6: Roles and Activities of Innovation Intermediaries Source: (Bessant & Rush, 1995; Hakkarainen & Hyysalo, 2016; Howells, 2006)

Hence the consolidation of the innovation intermediary roles to the TIS functions in Table 7.4 below.

Table 7.4: Ecosystem Activities and Intermediary roles

TIS (Innovation Ecosystem Actor) Functions (source of Leverage Points)	**Intermediary Roles and Actions** *Based on Lukkarinen et al. (2018), Kivimaa (2014), Howells (2006), Nilsson and Sia-Ljungstr€om (2013) and Kanda et al. (2018).*
Entrepreneurial Experimentation **[F1]**	Creating conditions for learning by doing and using; testing, validation and training; strategic planning and decision-making using triple-bottom-line or LCA
Knowledge Development **[F2]**	Knowledge gathering, processing, generation and re-combination; scanning, communication and dissemination of knowledge; education and training; provision of advice and training, technology assessment and evaluation, prototyping and piloting, information gathering and dissemination and branding
Knowledge Diffusion **[F3]**	
Guidance of Search **[F4]**	Articulation of needs, expectations and requirements; strategy development; advancement of sustainability aims; policy Implementation, foresight and diagnosis, identification of problems and opportunities; strategic planning and decision making.

TIS (Innovation Ecosystem Actor) Functions (source of Leverage Points)	**Intermediary Roles and Actions** *Based on Lukkarinen et al. (2018), Kivimaa (2014), Howells (2006), Nilsson and Sia-Ljungstr€om (2013) and Kanda et al. (2018).*
Market Formation **[F5]**	Acceleration of the application and commercialisation of new technologies; prototyping and piloting; investment in new Businesses. Identification of business opportunities.
Resource Mobilisation **[F6]**	Creation and facilitation of new networks; management of financial resources; identification and management of human Resource needs (skills); organisation of training programs, project design, management and evaluation, marketing, support And planning, sales network and selling, finding potential capital funding and organising funding or offerings.
Creation of Legitimacy **[F7]**	Gatekeeping and brokering; regulation (formal, informal and self-regulation), configuring and aligning interests; technology Assessment and evaluation; arbitration based on neutrality and trust; accreditation and standard setting: supporting the entry of new actors

ii. *Intermediary Characteristic Aspects:* besides just identifying the role and activities as an intermediary, outlining the capabilities and skills of that an innovation intermediary should possess to fulfil these roles is important. In the review these aspects are around the innovation intermediary's competencies, structural arrangements and boundary spanning capabilities shown in Figure 7.7. Notably, these same categorisations were utilised when it comes to the descriptive elements of the innovation ecosystem and the actions of the ecosystem actors, as it is important to map what the innovation intermediary has in terms of resources and capabilities. This helps strategise which activities can be undertaken immediately or in the near future in the innovation ecosystem due to what is readily available amongst the ecosystem actors.

This helps in alignment of the clear purpose and role of the innovation intermediary when it comes to different activities in the ecosystem. Additionally, the innovation intermediary can also take a back seat and assign a lead firm if need be - a scenario which occurs frequently in healthcare.

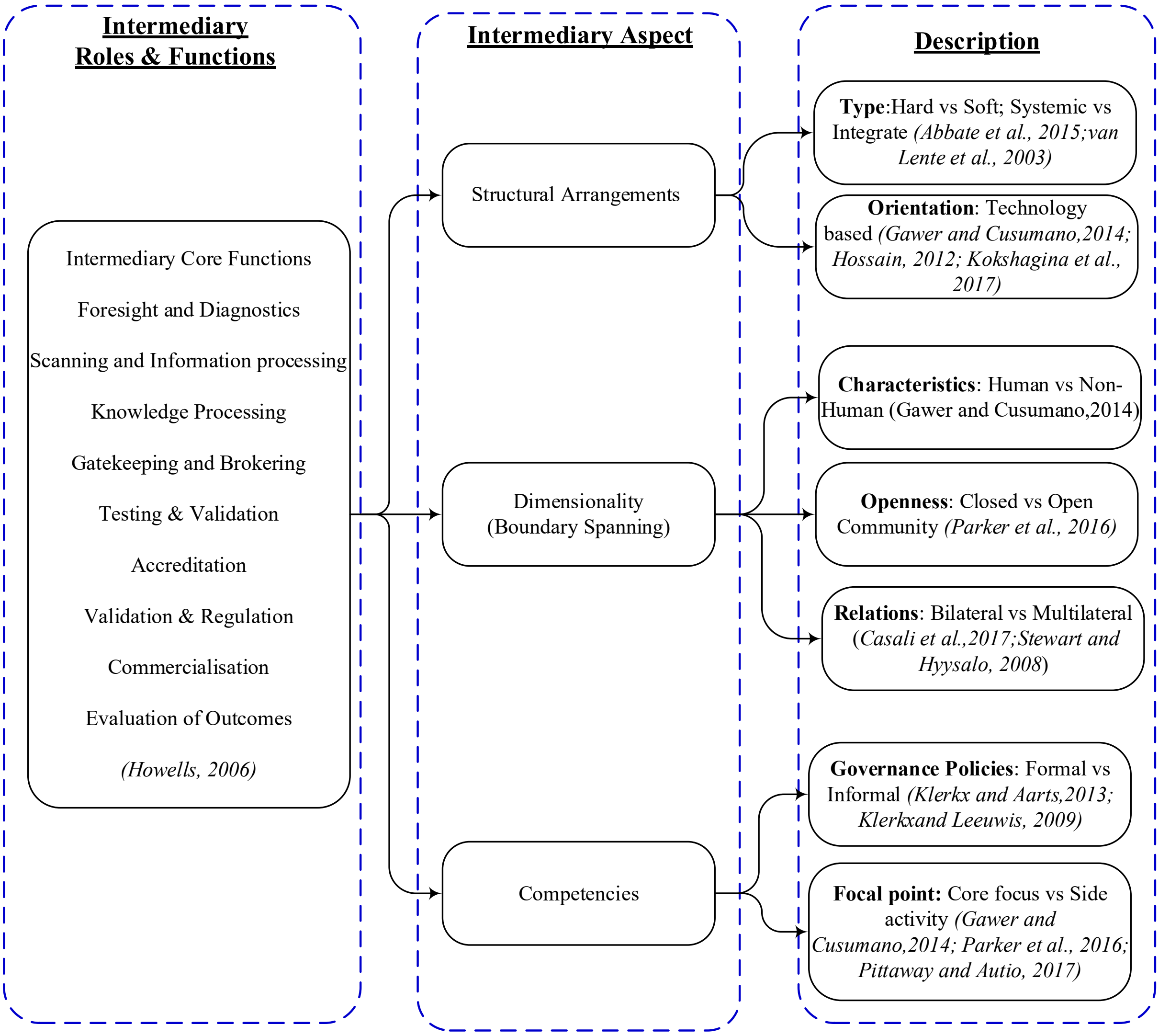

Figure 7.7: Innovation Intermediary Attributes

This goes further than just the roles and activities but the aspects and capabilities that the innovation intermediary needs to have in terms of assisting the actors in the ecosystem.

Cumulatively the subsystem of the framework for intermediation is shown in Figure 7.8 below.

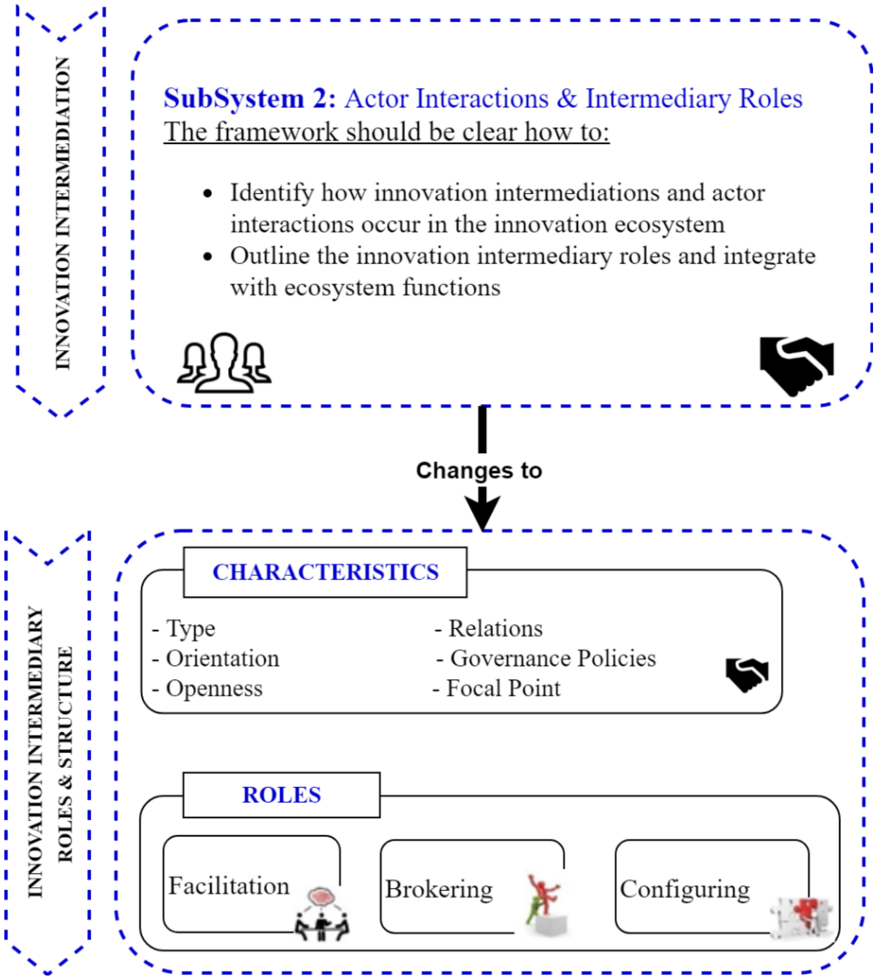

Figure 7.8: Subsystem 2 Framework Configuration

7.3.2.2 Functional Level: Subsystem 3-Knowledge Flows and Actor Interactions

This subsystem addresses what exactly the aspects that can be looked at in the innovation ecosystem are and how the intermediary can spur innovation. On the level of *what is to be mapped*-this was addressed by using the outline of TIS innovation functions as highlighted in Technology Innovation Systems (TIS) by Hekkert et al (2007a) and (Bergek, Hekkert, *et al.*, 2008). In this outlined functions include entrepreneurial activities, knowledge development, knowledge diffusion, market formation, resource mobilization, guidance of search and creation of legitimacy (Bergek, Hekkert, *et al.*, 2008; Hekkert *et al.*, 2007a). These are shown in Table 7.5. The functions assisted in the formulation of the interview guide are shown in Appendix E. Actions aligned with each of the activities are:

Table 7.5: Innovation Systems Functions and Activities

TIS Function	Activity description	Key activities
Entrepreneurial experimentation and activities **[F1]**	Tacit knowledge development of a more explorative, applied and varied nature and markets. Usually undertaken by entrepreneurs in the ecosystem	• Marginalized involvement and depth of involvement • Business involvement • Incentivised plans • discovering/creating opportunities • conducting technical experiments • delving into uncertain applications
Knowledge development- formal knowledge (learning) **[F2]**	Mechanisms of learning associated with *'learning by searching'* and '*learning by doing'*.	• Local knowledge • Research capacity • Research collaboration • Focus of knowledge development • Training and development of capabilities/capacity
Knowledge diffusion **[F3]**	Usage of networks in the exchange of information *'learning by interacting'* and *'learning by using'*	• Knowledge platforms and boundary spanning • Knowledge influence trajectory • Marginalized-centred knowledge
Guidance (influence in the direction) of search **[F4]**	Actions within the system that can positively affect the visibility and clarity of specific system needs	• Clear shared vision and goal • Supportive legislation
Market formation **[F5]**	Create protected spaces for new technologies Articulation of demand	• Institutional barriers • Institutional incentives
Resource mobilisation **[F6]**	Mobilisation of financial capital, human resources and complementary assets from other sources	• Financial mechanisms • Access to resources • Investment security • Access to Informal communities
Creation of legitimacy **[F7]**	Socio-political process of counteracting resistance to change through formulation of coalitions that push for the new technology[17]	• Reputation of investments for I4ID • Resistance to change • Government Involvement/ commitment

For the innovation intermediary, ending at just *what-is or what-was* does not suffice to address the main research question of this study which aims at how the intermediary can spur value co-creation in the ecosystem. Hence identifying what exactly affected the innovation ecosystem through identification of change attractors and leverage points is important. Aligning an innovation ecosystem as a CAS plays a key role in ensuring that points of gravity are identified in the ecosystem. This is done by identifying the characteristics of the main activities that caused pivotal changes in the ecosystem. This can either be positive or negative. To avoid confusion in this study between innovation systems and ecosystems, TIS functions will from this point onward be referred to as Innovation Ecosystem Functions. Referring to them in this chapter was important to highlight the theoretical basis of how the function categories were formulated.

[17] *Technology* includes both artefacts and knowledge. Artefacts may come in the form of hardware (e.g. products, design tools and machinery) or software (e.g. procedures/processes and digital protocols). Knowledge is partly found as competence within actors, codified in recipes (text and drawings) (Bergek, Jacobsson & Sandén, 2008)

7.3.3 Mapping Ecosystem Events to Ecosystem Functions

The events in the framework are not generic; although at first they are mapped from the outlined ecosystem functions, what is important to each ecosystem will differ. To have some format for the narratives the ecosystem life-cycle stages of Birth, Expansion and Self-renewal described by Moore (1993) in business ecosystems are used as a guide. The birth stage was associated with the initial concept of the ecosystem with key activities such as focussing on the acquisition of partners, market formation and stakeholder roles. The expansion stage aligned with the scaling and re-scaling of the scope of the ecosystem as it also competes against other ecosystems. Self-renewal or death looks at the balance and stability that incorporates new innovations or trends that may upend the ecosystem. This can also lead to the creation of other ecosystems or the death of the current ecosystem. This was taken as is in this study.

It should be noted that Moore had identified an additional lifecycle stage called Leadership. This stage aligned with the fight for control in an effort to guide the ecosystem's investment direction (Moore, 1993). However, in this framework the Leadership stage will not be focussed on when undertaking the ESA narratives. This is due to the assumption that facets of leadership cut across all stages of the life of the ecosystem. Hence in the study, Leadership becomes more of a role directed by the ecosystem actor that is designated as the innovation intermediary.

The events are identified through the formulation of the case study narratives, identifying the events and constructing a database containing events according to the lifecycle stage of the ecosystem. This is done by inductively identifying events through various sources such as journal articles, publications, theoretical or strategic reports and websites. Each event type is then mapped to a particular ecosystem function. They make up an intermediate level of representation that lies between the concrete literature reports and the abstract innovation ecosystems actor and innovation intermediary dynamics. A representation of the mapping process is shown in Figure 7.9.

Take note: an event can contribute to multiple ecosystem functions. For example, the setup and formulation of a policy may contribute to the functions of Knowledge Diffusion, Guidance of search and Support from Advocacy Coalitions. So, to avoid that type of ambiguity in this study, an event was explicitly distinguished by mentioning the various actions of the event structure. That is, the creation of a community around the policy contributes to Knowledge Diffusion, the issues and aspects it addresses contribute to Guidance of search and the lobbying activities it undertakes are under Support from Advocacy Coalitions.

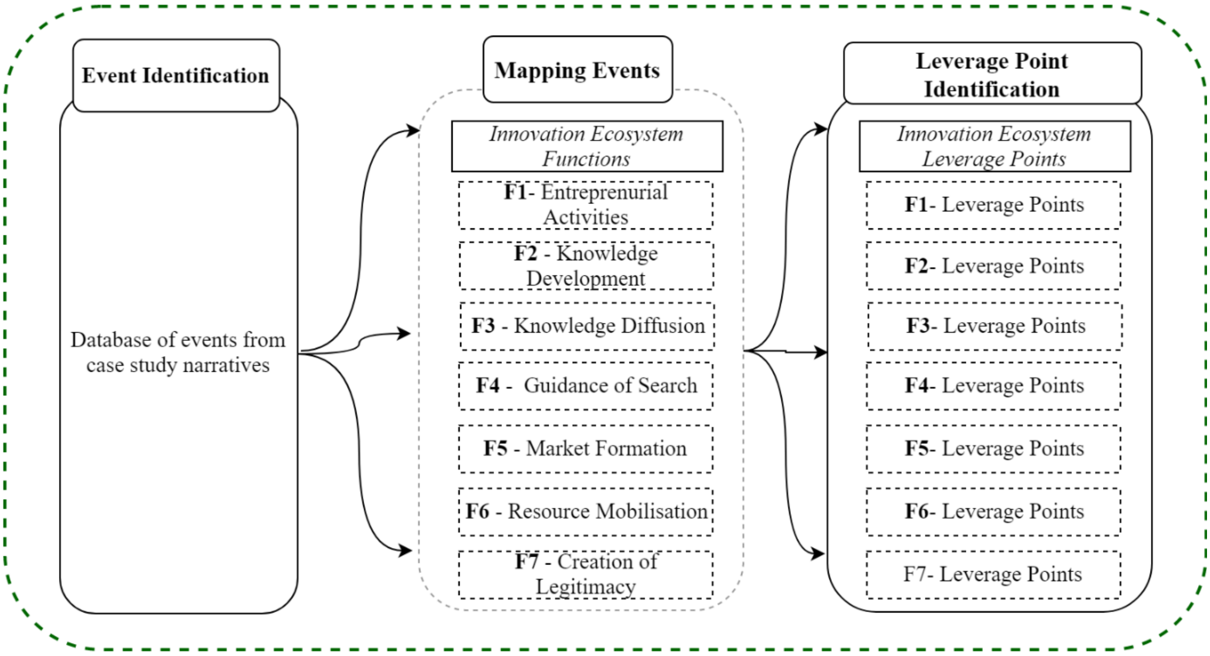

Figure 7.9: Mapping Process of Leverage Points to Inform Ecosystem Evolution Framework

Additionally, an event's contribution can be either positive or negative – the study does not only focus on the positive events. A negative event is not necessarily a bad thing as this serves to highlight and learn about aspects that the innovation intermediary and ecosystem actors can address in order to improve the chances of achieving sustainability in the innovation ecosystem. Operationalisation of the ecosystem functions and attractors in this way is the cumulative result of multiple case studies. With each case study, the event structure analysis resulted in a more developed operationalisation scheme[18].

The third subsystem of the framework is shown in Figure 7.10.

[18] Such a methodology was employed by (Hekkert, Suurs, Negro, *et al.*, 2007a; Suurs, 2009) although the alignment was event history analysis.

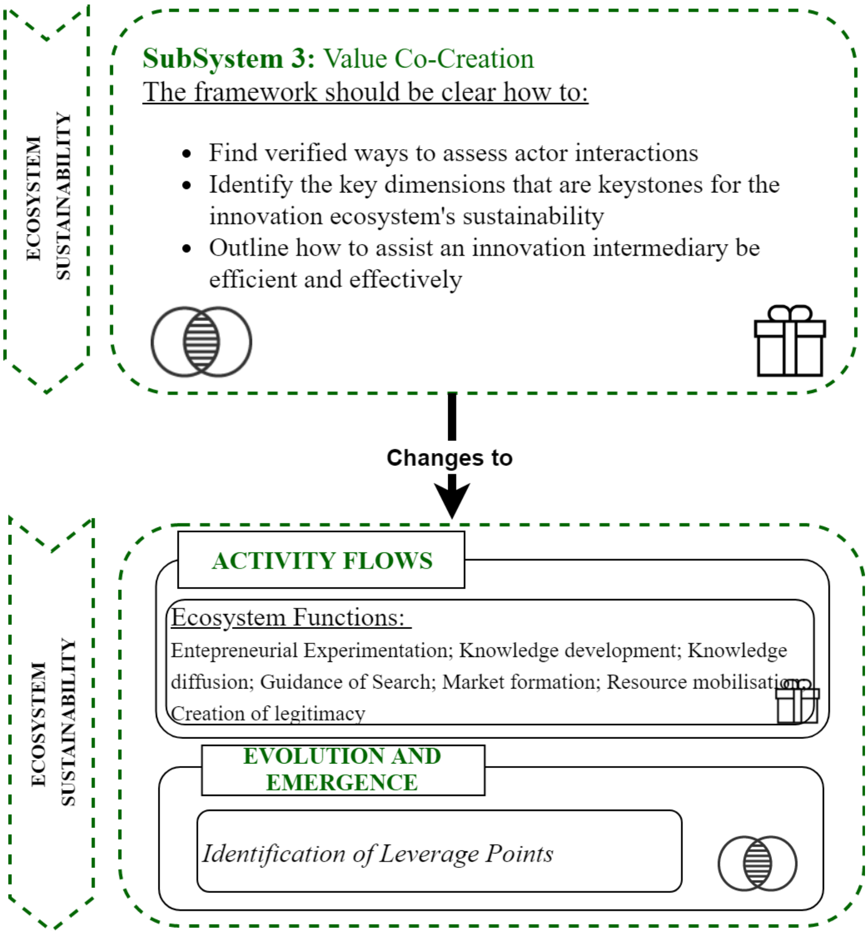

Figure 7.10: Subsystem 3 Framework Configuration

7.4 Synthesis of Concepts into an Integrated Framework

It is necessary to portray how overall the subsections come together in a holistic way. As mentioned before, SSM was a guide for the whole study but aspects of it are also used in the development of the framework. This acts as a nested function of sorts where important aspects of the analysis of the innovation ecosystem such as the description of the ecosystem, its actors and the historical events in the ecosystem feed into the attractor and leverage point identification. Though there is some logical order in the subsystems it does not mean that it is a closed process step-wise. For example, it is important to start with the purpose of the innovation ecosystem but as this is a CAS, that means due to various externalities and internal dynamics this is an everchanging and dynamic process, which can require repositioning the ecosystem, finding new stakeholders or temporarily removing some actors. The linearity of the representation of the process is thus far from the way in which innovation works but has value as a heuristic of the process. The tabulated sub-systems and information sheets are shown in Appendix C.

Table 7.6 descriptively depicts the integration and the key questions and main indicators of each subsystem that has been mentioned in the conceptual framework. Of note is that the leverage points will be identified through an iterative process from the case studies.

Table 7.6: Integrated Conceptual Framework

Sub-System	Dimension	Aspect	Sub-Aspect	Key Enquiry and Activities
Subsystem #1 Innovation Ecosystem Structure and Arrangement	*Aim of the ecosystem*	Ecosystem Strategy	Strategic Alignment	What is the purpose of the ecosystem?
				What is the aim that the ecosystem is addressing?
	Structural arrangements	Ecosystem Construction	Formulation of the Ecosystem	Is the ecosystem formulated from i. Structure? ii. Affiliation?
			Actors in the ecosystem	Which actors are part or the ecosystem or required? • *Community*-Entire species available within the (healthcare) ecosystem environment • *Technology Digital species* - Hardware and software responsible for the information interchange; health systems and health information resources • *Biological species* - Users/ people in the ecosystem • *Economic species* - Companies and Institutions
	Field	Competencies in and around the Ecosystem	Ecosystem life-cycle stage	Birth, Growth, Self-Renewal
	Dimensionality	*(Boundary Spanning) of the Innovation ecosystem*	**What-was** *Historical innovation projects undertaken under the same intervention*	What value was created? Who benefited? Who lost? Who stopped the change? Who did the transformation? What are the advances in technology and policy that have occurred since inception?
			What-is *Current state*	What is important? What is to be achieved? What is the benefit and how is it attained? Who can stop or change the process? Who will do the transformation, or make it happen physically? What are the restrictions are there in the immediate surroundings
			What should be *Strategic goals of the ecosystem*	How does the ecosystem aim to align to the National Innovation Strategies and Goals? e.g. Sustainable Development Goals

Sub-System	Dimension	Aspect	Sub-Aspect	Key Questions/ Indicators
			Which role is best to assist the innovation ecosystem and actors in various capacities?	
Subsystem #2 Innovation Intermediation	*Intermediary Roles and Activities*	<u>**Facilitation**</u>  **Roles:** *Promoter, Facilitator, Leader*	Entrepreneurial Experimentation **[F1]**	Creating conditions for learning by doing and using Testing Validation and training Strategic planning Decision making using triple-bottom-line or LCA
			Knowledge development and diffusion **[F2]**	Knowledge gathering Knowledge processing Knowledge generation and re-combination Scanning Communication and dissemination of knowledge Education and training Provision of advice and training Technology assessment and evaluation Prototyping and piloting Information gathering Information dissemination Branding
		<u>**Brokering**</u>  **Roles:** *Conductor, Goalkeeper*	Knowledge diffusion **[F3]**	
		<u>**Configuring**</u>  **Roles:** *Architect, Developer, Auctioneer*	Guidance of search **[F4]**	Articulation of needs Expectations and requirements Strategy development Advancement of sustainability aims Policy implementation Foresight and diagnosis Identification of problems and opportunities Strategic planning and decision making.
			Market formation **[F5]**	Acceleration of the application Commercialisation of new technologies Prototyping and piloting Investment in new businesses Identification of business opportunities.
			Resource mobilisation **[F6]**	Creation and facilitation of new networks Management of financial resources

Sub-System	Dimension	Aspect	Sub-Aspect	Key Questions/ Indicators
				Identification and management of human Resource needs (skills) Organisation of training programs Project design Project management Project evaluation Marketing Support Planning Sales network and selling Finding potential capital funding and organising funding or offerings
			Creation of Legitimacy **[F7]**	Gatekeeping and brokering Regulation (formal, informal and self-regulation) Configuring and aligning interests Technology Assessment and evaluation arbitration based on neutrality and trust Accreditation and standard setting Supporting the entry of new actors
			What are the required capabilities of the Innovation Intermediary?	
	Innovation Intermediary Characteristics	**Structural Arrangements**	Type	Hard vs Soft Systemic vs Integrate
			Orientation	Technology based vs Non-technology based
		Dimensionality	Characteristics	Human interface vs Non-human interface
			Openness	Closed vs Open
			Relations	Unilateral vs Bilateral vs Multilateral
		Competencies	Governance Policies	Formal vs Informal
			Focal point	Core focus vs Side activity

Sub-System	Dimension	Aspect	Activity Descriptions	Key Questions/ Indicators
		Ecosystem Innovation Functions		***Areas of learning and sources of innovation***
Subsystem #3 Activity and Knowledge Flows	*Activity Flows in the ecosystem*	Entrepreneurial Experimentation **[F1]**	Tacit knowledge development of a more explorative, applied and varied nature and markets. Usually undertaken by entrepreneurs in the ecosystem	• Marginalized involvement and depth of involvement • Business involvement • Incentivised plans • discovering/creating opportunities • conducting technical experiments delving into uncertain applications
		Knowledge development **[F2]**	Mechanisms of learning associated with *'learning by searching'* and '*learning by doing'*.	• Local knowledge • Research capacity • Research collaboration • Focus of knowledge development Training and development of capabilities/capacity
		Knowledge diffusion **[F3]**	Usage of networks in the exchange of information *'learning by interacting'* and *'learning by using'*	• Knowledge platforms and boundary spanning • Knowledge influence trajectory Marginalized-centred knowledge
		Guidance of search **[F4]**	Actions within the system that can positively affect the visibility and clarity of specific system needs	• Clear shared vision and goal Supportive legislation
		Market formation **[F5]**	Create protected spaces for new technologies Articulation of demand	• Institutional barriers Institutional incentives
		Resource mobilisation **[F6]**	Mobilisation of financial capital, human resources and complementary assets from other sources	• Financial mechanisms • Access to resources • Investment security Access to Informal communities
		Creation of Legitimacy **[F7]**	Socio-political process of counteracting resistance to change through formulation of coalitions that push for the new technology	• Reputation of investments for I4ID • Resistance to change Government Involvement/ commitment
	Ecosystem, Evolution and Emergence	Leverage Points, Change attractors, feedback and History of the Ecosystem	**Identification of Leverage points**	What activities are there to watch out for to spur value co-creation and ecosystem emergence?

The descriptive blocks of the conceptual framework can be mapped into the appropriate ecosystem activities by an intermediary organisation as shown in Figure 7.11.

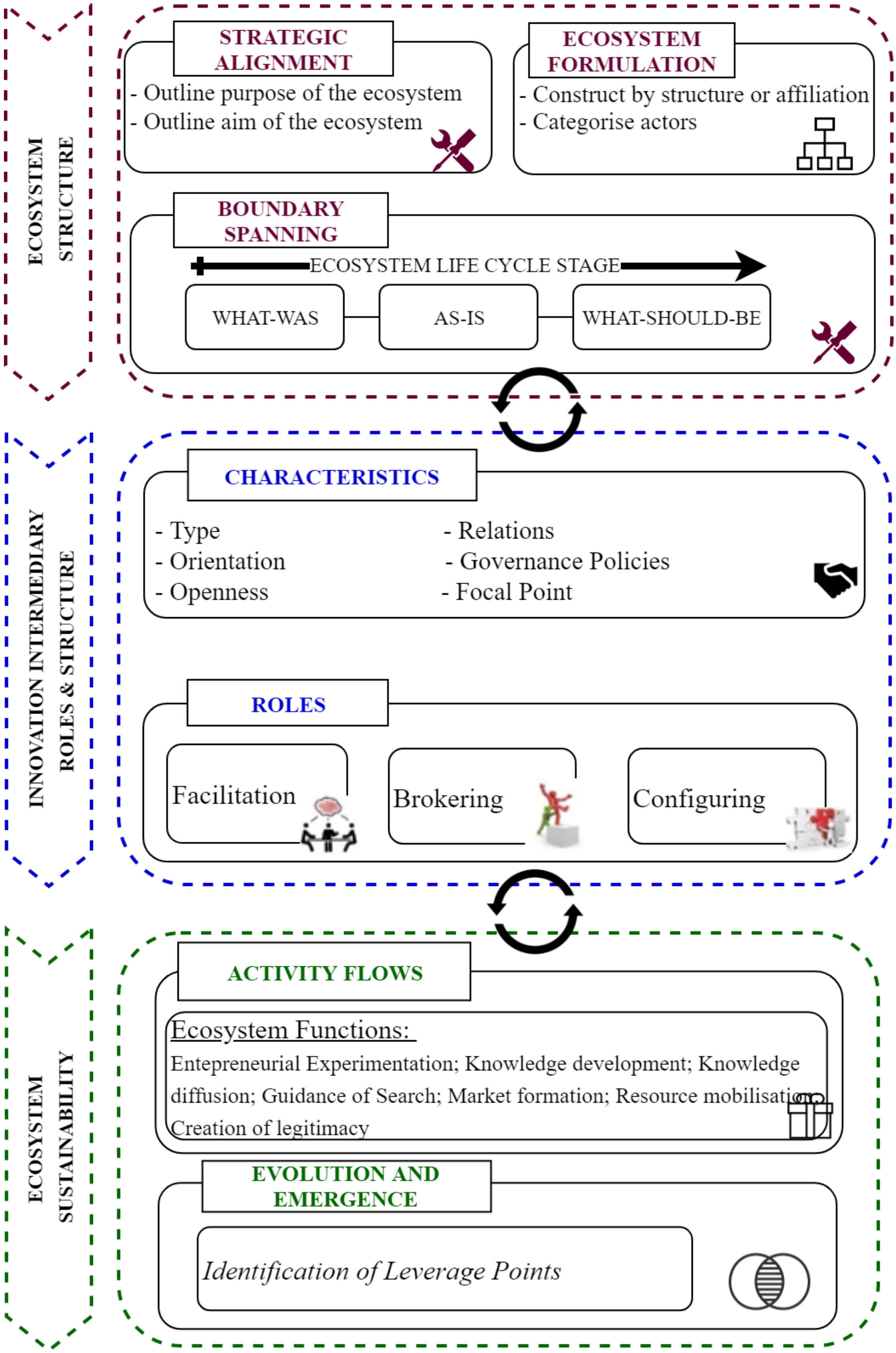

Figure 7.11: Innovation Ecosystem Emergence and Evolution Framework

7.5 Verification of the Framework against User Requirements

A process of verification is necessary for the framework. This is done in two primary ways: through looking at the outlined overall features and requirements that a framework should exhibit mentioned at the beginning of the chapter and through looking at the various subsystem requirements. The verification is the first stage that is undertaken to make sure that conceptually and theoretically the framework is sound. Nevertheless, the framework also went through empirical evaluation and validation.

7.5.1 Conceptual Framework Overall Verification

The key features of a conceptual framework that are deemed key in section 7.1 are shown in the following ways:

1. *Integrative role:* the subsystems have been individually addressed and explained in terms of the relevance to the study and the relationships. This is cumulatively shown in Table 7.4 and Appendix G.
2. *Evolving:* the framework looks at aspects that continuously address the status quo of the ecosystem hence it is not static.
3. *Constructability:* the various innovation ecosystem constructs, innovation intermediary characteristics, technology innovation systems and knowledge management processes incorporated into the framework ensure that it is a multidisciplinary construct, bringing about consensus among the different fields and various field such as complexity science. Moreover, how data is collected in terms of addressing the various aspects suggested by the framework can be both of a qualitative and quantitative nature. The idea of this framework is to provide the foundation for an evaluation process that can integrate heterogeneous sources and types of data to create a compelling picture of how communities and networks create value for their members, for hosting organizations, and for sponsors.
4. *Interpretative capacity:* the developed framework gives intermediary organisations a starting point for dealing with innovation ecosystems knowledge activities. The aim is to define the route which must be taken by intermediary organisations in ensuring that a platform-centric innovation ecosystem spurs innovation and is sustainable.
5. *Indeterministic*: though the framework will not enable prediction in the innovation process, the identified change attractors will likely aid in improving the outcome of certain events and activities in the ecosystem.
6. *Understanding*: the conceptual framework was designed with the aim to understand how to increase the sustainability of the innovation ecosystem. Different dynamics and aspects addressing that were highlighted.
7. *Capacity for modification*: this conceptual framework was conceptualised in the hope that after the empirical work is undertaken an updated framework will be presented.

The next section looks at the requirements that are key for the framework when it comes to use in the analysis of innovation ecosystems.

7.5.2 Ecosystem Emergence Framework Internal Requirements Verification

There are various requirements that were outlined in the literature which fed into the description of the framework in section 7.2 and section 7.3. These various requirements come from innovation ecosystems literature and the gaps that the study was looking to address. Therefore, the following factors verify the framework and its subsystems in Table 7.7 below.

Table 7.7: Ecosystem Emergence Framework Requirement Verification

		Description of Requirements *(linked to chapter)*	**Framework Verification** *(how requirement is met in the framework)*	**Framework Aspect** Ecosystem Structure description	Activity Description (TIS Functions)	Knowledge Flows (4F- Field, Form, Flow, Function)	Current state and Imagined state (SSM)	Leverage Point Identification (CAS) +(ESA)	Innovation intermediary roles & activities
Functional Requirements	**FR1**	The framework should enable efficient resource allocation *(Chapter 1.2)*	The framework has outlined a process to identify ecosystem actor activities		✓	✓	✓	✓	✓
	FR2	The framework should encourage and enable the joint design of sustainable (healthcare) innovation ecosystems *(Chapter 1.2)*	The framework outlines the key activities that have affected the ecosystem in various ways		✓		✓	✓	✓
	FR3	The framework should identify how actors collaborate *(Chapter 1.2)*	The framework identifies ways to foster coordination and collaboration between various stakeholders from various disciplines that are responsible for propagating innovation	✓	✓		✓		✓
	FR4	The framework should provide a basis for consensus building and clarity between intermediaries and their roles in an innovation ecosystem *(Chapter 5.7)*	This functional approach was utilised in the framework		✓	✓	✓		
	FR5	The framework should go beyond just metaphoric symbolisms *(Chapter 3.1)*	The framework offers ways to depict and interpret actor interactions	✓	✓	✓	✓	✓	✓
	FR6	The framework should provide a basis to include intangible actor interactions and knowledge flows *(Chapter 4.4)*	Narratives are used in the framework as a key source of identifying the leverage points in the ecosystem				✓	✓	

		Description of Requirements (linked to chapter)	Framework Verification (how requirement is met in the framework)	Framework Aspect					
				Ecosystem Structure description	Activity Description (TIS Functions)	Knowledge Flows (4F- Field, Form, Flow, Function)	Current state and Imagined state (SSM)	Leverage Point Identification (CAS) +(ESA)	Innovation intermediary roles & activities
Design Requirements	**DR1**	The framework should embrace complexity in the design process *(Chapter 1.2)*	The framework utilises methods aligned with complex systems	✓				✓	
	DR2	The framework should have a multidisciplinary approach guidance *(Chapter 2.2)* and the non-linear relationships and states of the ecosystems *(Chapter 3.1)*	The framework integrates and merges various tools for holistic	✓	✓	✓	✓	✓	✓
	DR3	The framework should address the theoretical underpinnings that address the different relational dynamics that occur amongst the ecosystem actors *(Chapter 1.6)*	The framework combines theoretical underpinnings to inform the identified leverage points	✓	✓	✓	✓		✓
	DR4	The framework should assist in understanding how the ecosystem actors interact, create value and co-evolve *(Chapter3.1)*	The framework brings some clarity to multi-stakeholder situations		✓	✓	✓	✓	
	DR5	The framework should acknowledge the evolution between these elements *(Chapter 3.1)*	The framework acknowledges the life cycle stages of the ecosystem evolution across all interactions	✓	✓	✓	✓	✓	✓
	DR6	The framework should use a structuralist approach to conceptualise the ecosystem construct *(Chapter 3.1, 3.6, 4.2)*	There is the use of design tools that assist with structural aspects of the ecosystems and also ways of how to trace the way that the ecosystems emerge and evolve.	✓	✓	✓	✓	✓	✓
	DR7	The framework should clearly outline the roles and functions of the innovation intermediary *(Chapter 4.2)*	The framework outlines from literature the roles and activities of an innovation intermediary						✓
	DR8	The framework should provide guidelines of how the ecosystem can learn from its past or past projects done in other ecosystems *(Chapter 4.4)*	There is the use of Causal Loop diagrams and ecosystem mapping to inform the ecosystem management.				✓	✓	
	DR9	The framework should have a sound theoretical base *(Chapter 3.1)*	The framework is based on verified theoretical aspects	✓	✓	✓	✓	✓	✓

		Description of Requirements (*linked to chapter)*	**Framework Verification** *(how requirement is met in the framework)*	**Framework Aspect**					
				Ecosystem Structure description	Activity Description (TIS Functions)	Knowledge Flows (4F- Field, Form, Flow, Function)	Current state and Imagined state (SSM)	Leverage Point Identification (CAS) +(ESA)	Innovation intermediary roles & activities
	DR10	The framework should provide a method for extracting and identifying key activities that affect the relational behaviour amongst ecosystem actors *(Chapter 2.2 and Chapter 4.4)*	The framework provided a relevant procedure and method for extracting and identifying leverage points in the ecosystem. It goes beyond just identifying events but categorises them.	✓	✓	✓	✓	✓	✓
	DR11	The framework should map the ecosystem value co-creation process flows *(Chapter 2.2)*	The framework has ways to identify knowledge and process flows in the ecosystem	✓	✓	✓	✓	✓	✓
User Requirements	**UR1**	The framework assists the user to carry out some form of ecosystem management *(Chapter 1.2)*	The framework identifies the roles and activities of an innovation intermediary						✓
	UR2	The framework must assist management to proactively be aware of the dynamics occurring in the ecosystem *(Chapter 4.2)*	The history and past actions of actors in an ecosystem whish are identified by the framework can inform ecosystem management	✓				✓	✓
	UR3	The framework must assist management to check the capabilities of the intermediary firm *(Chapter 5.2)*	The capabilities of the innovation intermediary are matched with the role of the intermediary		✓	✓			✓
Attention Points	**AP1**	The framework should address governance issues *(Chapter 1.6)*	The need to address governance issues has been highlighted but it is up to the intermediary		✓	✓			
	AP2	The framework should consider the use of technology in ecosystem management *(Chapter 3.1)*	The framework highlighted this aspect, but it is not a prerequisite for using the framework	✓				✓	
	AP3	The framework does not need to provide a predictive way of what happens when particular activities and actions occur in the ecosystem *(Chapter 1.3: Chapter 4.4)*	The current framework does not have any predictive capabilities but forms a foundation that aligns with the premise is that even in a complex system, if boundaries are defined a level of prediction is possible				✓	✓	

		Description of Requirements *(linked to chapter)*	**Framework Verification** *(how requirement is met in the framework)*	**Framework Aspect**					
				Ecosystem Structure description	Activity Description (TIS Functions)	Knowledge Flows (4F- Field, Form, Flow, Function)	Current state and Imagined state (SSM)	Leverage Point Identification (CAS) +(ESA)	Innovation intermediary roles & activities
	AP4	The framework shows when value has been successfully appropriated *(Chapter 3.1)*	The framework does not evaluate any measure of success, but it does identify what activities are key to ecosystem sustainability which is directly linked to value appropriation		✓	✓	✓	✓	
Boundary Conditions	**BC1**	The framework should assist ecosystem actors that have shared institutional logics with a set of common rules of how to participate in the ecosystem *(Chapter 4.3)*	The framework outlines the importance of considering each actor's value requirements and the ecosystem's value appropriation and co-creation aspects. However, focus is on the intermediary and it does not set rules of engagement for every actor.				✓	✓	✓
	BC2	The framework does not aim to differentiate the ecosystems construct from other systems of innovation constructs (Chapter 3.1)	The framework utilises the innovation systems construct to understand how the dynamics in innovation ecosystems can be analysed and explained		✓	✓			
	BC3	The framework should be clear about which aspects, artefacts and dynamics are being investigated *(Chapter 4.4)*	The framework gives an outline of some activities, but this can change according to the ecosystem under study	✓	✓	✓	✓	✓	✓
	BC4	The framework provides frequency of interactions between specific ecosystem actors as measure of the nature and quality of ecosystem relationships *(Chapter 2.2 and Chapter 3.1)*	The framework does not focus on frequency but on the structure of the events to understand the dynamics around knowledge flows in the ecosystem.				✓	✓	

Thus, the developed framework is preliminarily deemed as adequate, based on how it exhibits the internal key features of frameworks.

7.6 Chapter Conclusion

This chapter presented the design and development of the conceptual framework. It gave an overview of the theoretical aspects that were selected by the researcher for inclusion into the conceptual framework. The prevailing literature forms the foundation of the framework as it is developed from the culmination of findings in the preceding chapters of the literature using SSM as a guide. This approach takes into consideration the complexity of innovation ecosystems. The framework makes it easier to comprehend which activities can be attractors and affect the emergence and sustainability of the ecosystem. It seeks to simplify the visualisation of key concepts and processes required for the management and sustainability of an innovation ecosystem.

The product of this chapter is an untested framework which has been internally verified. The verification was undertaken in two primary ways. Firstly, through aligning aspects that were outlined for conceptual frameworks from extant work and secondly from the functional requirements, user requirements, design requirements, boundary conditions and attention points that were identified in the literature review that would address the research gaps the framework aims to answer.

In the next chapter, the conceptual framework is validated. The fieldwork provides insight into the practical adoption of the framework as well as highlighting areas that require further investigation and improvement. In the following chapter, an evaluation of the framework through well documented South African mHealth cases MAMA and MomConnect will be outlined and the means of externally validating the framework is discussed as well as the validation route that influenced the iterative development of the final framework and tool.

Chapter 8: Initial Evaluation Process

"*Failure is success if we learn from it.*" — Malcolm Forbes

This chapter has two distinct purposes. Firstly, it is to present a preliminary desktop evaluation where the framework is applied to a case study to test the usefulness of the framework. The case selected was the Maternal Action for Mobile Alliance and MomConnect. This was done to highlight the insight that can be developed through tracing the emergence of an innovation ecosystem and how an innovation intermediary plays a key role in that process. Secondly, the key activities (leverage points) that caused the evolution of the platform in different trajectories were also identified to point out ecosystem aspects for platform sustainability. The evaluation process is used to refine the Ecosystem Evolution and Emergence Framework. This is a starting point for categorising the generic change attractors that an intermediary can focus on in a (platform-centric) innovation ecosystem and the first input of 5th stage of SSM as shown in Figure 8.1.

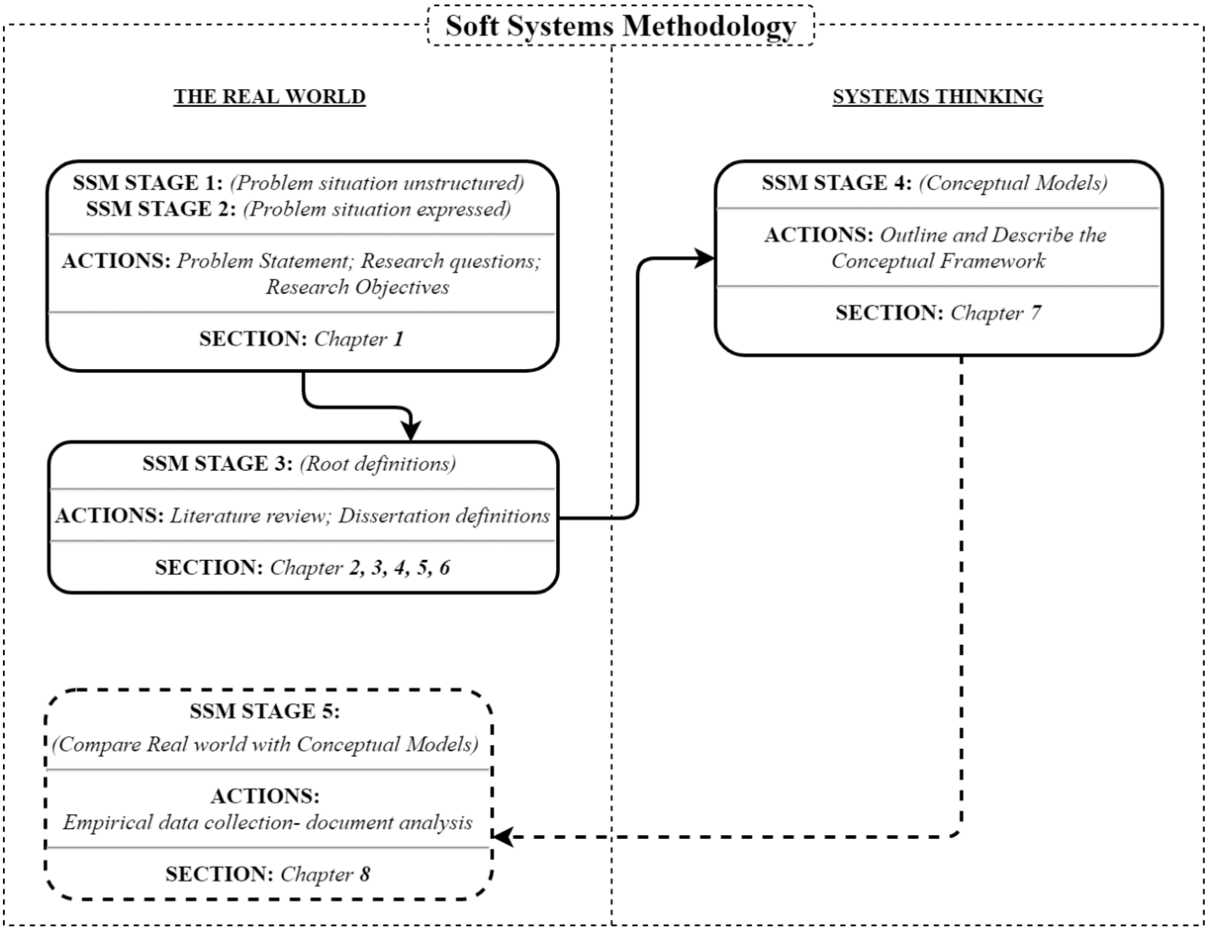

Figure 8.1: SSM Stage Descriptions and Dissertation Alignment

The chapter will start with outlining the evaluation process and how each stage added to the final framework. Next, a brief outline of the contextual issues that led to the platforms and ecosystems around them being built is given in section 8.2.

8.1 Conceptual Framework Evaluation Methodology

The credibility of the findings in this study stemmed from a utilising a number of methods using various sources (Creswell, 2013; Yin, 2009). This was done through triangulation of the literature review; seminars with innovation experts[19]; document and archival records analysis; qualitative interviews and case narratives of the MAMA, MomConnect and DHIS2 communities. This technique entailed studying and understanding phenomena through more than one method in order to increase the comprehensiveness and validity of this study.

The complete methodology for evaluating the initial subjective conceptual framework towards the final framework was more fully explained in Chapter 2.3 and illustrated in Figure 2.4.

8.2 Case Study Context

Globally, especially in the developing world, many women have limited or no access to basic health information that is required for them to have safe pregnancies and healthy babies (Seebregts, Seebregts, Barron, *et al.*, 2016). South Africa is no different as it has high rates of infant and maternal mortality. The mortality rates are 25 per 1,000 live births and maternal mortality of 152 per 100,000 births (Dorrington et al., 2018). Most of these deaths are preventable and hampered by access to information (Peter, 2018; Peter et al., 2018). Hence, various initiatives have been launched to address such disparities. The Campaign on the Accelerated Reduction of Maternal and Child Mortality in Africa (CARMMA) strategy was launched by the African Union[20] in 2009 and adopted in 2012 by South Africa[21]. The aim was to reduce maternal and child mortality and achieve positive health outcomes. Locally, the South African National Department of Health (NDoH) had a Ten Point Plan to overhaul the health system[22] with one of the mandates to support innovative solutions that aim to reduce maternal, infant and child mortality. Solutions cover improving the supply chain, access to required services and educating the population through sending timely health-related information.

This has given rise to a sizeable number of small-scale digital health programs for technical platforms implemented by healthcare providers and operators (Botha & Booi, 2016). Various mHealth projects utilise mobile feature phones as tools in the information dissemination process (Botha & Booi, 2016). The uptake of using mobile phone-based solutions was due to South Africa's telecommunications sector being one of the most advanced in Africa and mobile usage being high. In South Africa most people including pregnant woman have either a personal cell phone or have access to cell phones. In 2018, the South African national 3G coverage was 99% whilst the smartphone penetration was 81.7%[23]. With such high mobile penetration rates even in rural areas, this readily provided a large network through which to reach pregnant women and new mothers. This builds banks of content that can be repurposed and offer transferable user insights and operational expertise (South African National Department of Health, 2016).

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[19] This fellowship was undertaken at Aalborg University; the researcher was hosted by the Innovation, Knowledge and Economics group. This was the first place that the framework was presented, and feedback was given on the relevance as well as areas of emphasis which assisted in refining the framework. Seminars were as shown in the link https://www.fak.samf.aau.dk/nyheder/Nyhed/africalics-research-seminar-on-innovation-and-economic-development.cid405694

[20] https://au.int/en/pressreleases/20200206/campaign-accelerated-reduction-maternal-mortality-africa-carmma-2009-2019

[21] http://www.kznhealth.gov.za/family/CARMMA_South_Africa_Strategy.pdf

[22] https://health-e.org.za/wp-content/uploads/2014/08/SA-DoH-Strategic-Plan-2014-to-2019.pdf

[23] https://www.icasa.org.za/legislation-and-regulations/state-of-ict-sector-in-south-africa-2019-report

8.2.1 Mapping Events to Ecosystem Functions

This study evaluated the EEEF developed in this dissertation. This was done by looking at two technological interventions aimed at disseminating information and educating pregnant and postnatal women. The healthcare innovation ecosystems of the platforms served as the starting stage of framework evaluation and refinement. These are the Mobile Alliance for Maternal Action (MAMA) South Africa[24] and the MomConnect[25] programs. These programs are an example of how one project paved the way for the other to function properly – as MAMA amassed years of testing and implementation which were eventually leveraged in the design and implementation of MomConnect. This is because MomConnect evolved from MAMA.

The cases in this study were assessed using Event Structure Analysis across the three distinct stages of an ecosystem which are ecosystem birth (*i.e. creation*), ecosystem expansion (*i.e. growth*) and ecosystem self-renewal (*i.e. death, sustainability, or rebirth*) as identified by Moore (1993) as Birth, Expansion and Self-Renewal. In this study the ecosystem can either die or evolve to a different state. This is divided into 3-year segments in the case study. The narratives of MAMA and MomConnect are conducted individually and the analysis utilised the proposed EEEF.

The conceptual framework of the identified innovation ecosystem functions (described in Chapter 7) was used heuristically as the identification of the events in the text. These were now further mapped and clustered to create groups and categories that were deemed leverage points. This was done by inductively identifying events through journal articles, theoretical reports and websites aligned with two maternal mobile health (mHealth) platforms. The outlined and listed events provided an overview of the type of function(s) related to an event and the activity aligned with that event. Each event type was mapped to a particular ecosystem function. The limitations of this data gathering method were acknowledged but the focus was more on the merits as these are well documented cases.

The two mHealth platforms that were selected for this purpose were selected based on data availability due to:

1. a substantial number of research studies undertaken around the platforms
2. open access to numerous publications and technical reports from the platform implementers and stakeholders such as the National Department of Health (NDoH). The list is in Appendix D.
3. the scale and reach of the platforms to over 2 million pregnant and post-natal mothers
4. the operational context.

An additional important aspect is to highlight the events that show how MAMA paved the way for MomConnect and how the innovation ecosystems around them changed. Hence, the focal point was on a range of activities around the maternal health innovation ecosystem. Of note is that this

[24] https://www.babycenter.com/mission-motherhood/partners/mama-mobile-alliance-for-maternal-action/

[25] http://www.health.gov.za/index.php/mom-connect

evaluation is the first stage of identifying the initial leverage points that feed into the final EEEF. There are consequently two other stages that will stem from the empirical data collection process.

Throughout the narratives the 7 IS functions were identified, collated and coded accordingly. The identified events for MAMA and MomConnect are in Appendix H and Appendix I respectively. The functions were mapped as entrepreneurial experimentation (**F1-ENT**), knowledge development (**F2-KDev**), knowledge diffusion (**F3-KDif**), guidance of search (**F4-GS**), market formation (**F5-MF**), resource mobilisation (**F6-RM**), creation of legitimacy (**F7-CL**).

8.2.2 Mobile Alliance for Maternal Action South Africa (MAMA SA)

8.2.2.1 Ecosystem Birth: 2011-2012

In 2011, the global Maternal and Child Survival Program[26] launched the MAMA project in South Africa. The aim of MAMA South Africa was to enable women to improve self-monitoring of their own and their infant's health, and to provide them with knowledge of their rights within the healthcare system, address information disparities and improve the quality of healthcare (Peter et al., 2018) **[F1-ENT]**. Information was sent to expectant and early stage mothers on the stages of pregnancy, birth and early childhood development **[F3-KDif]**. The strategy was that in engaging and empowering these women, they make healthy decisions for themselves and their children which assist the Department of Health strategy mandate **[F1-ENT, F7-CL]**.

To bring MAMA South Africa to fruition, a public-private consortium was established. The consortium had various responsibilities **[F7-CL].** Content and funding were primarily undertaken by international organisations whilst the technology implementations and the Monitoring and Evaluation was undertaken by South African companies **[F2-KDev]**. The main funders were international organisations that were involved in funding such projects (USAID, Johnson & Johnson, United Nations Foundation) **[F6-RM, F7-CL].** The South African implementing partners were mobile network operators (Praekelt Foundation, Cell-Life and Always Active Technologies) [**F6-RM**]. Praekelt Foundation is an African non-profit organization dedicated to using mobile technology to improve the lives of people living in poverty[27].=, whilst Cell-Life was a spinout company from the University of Cape Town which was linked to the university [**F7-CL**] that was launched through funding from the Vodacom Foundation [**F2-KDev, F5-MF, F6-RM**]. The Vodacom Foundation also offered a pool of 6,000 early adopters who got to subscribe and test MAMA[28] [**F5-MF**]. This university linkage saw the company having an accessible pool of human resources as some University of Cape Town (UCT) postgraduate students were employed by the company **[F6-RM**], whilst others were undertaking research projects aligned with the goals of the company[29] [**F2-KDev, F7-CL**]. Unfortunately, Cell-Life closed down in 2008 [**F6-RM**] and handed over their research to the Research Contracts and Innovation Centre [**F3-KDif**]. MAMA had no core firm to act as an innovation intermediary [**F4-GS**]. It was a consolidated effort with an implementing partner with signed memorandums of understanding with the NDoH. The government was kept informed of the

[26] https://www.mcsprogram.org/

[27] https://www.praekelt.org/

[28] http://www.wrhi.ac.za/media/detail/mobile-alliance-for-maternal-action-mama

[29] http://www.rci.uct.ac.za/rcips/innovation_achievements/spinout_companies/celllife

program activities, but they were not a key partner until transitioning to MomConnect. The actor ecosystem for MAMA is shown in Figure 8.2 below:

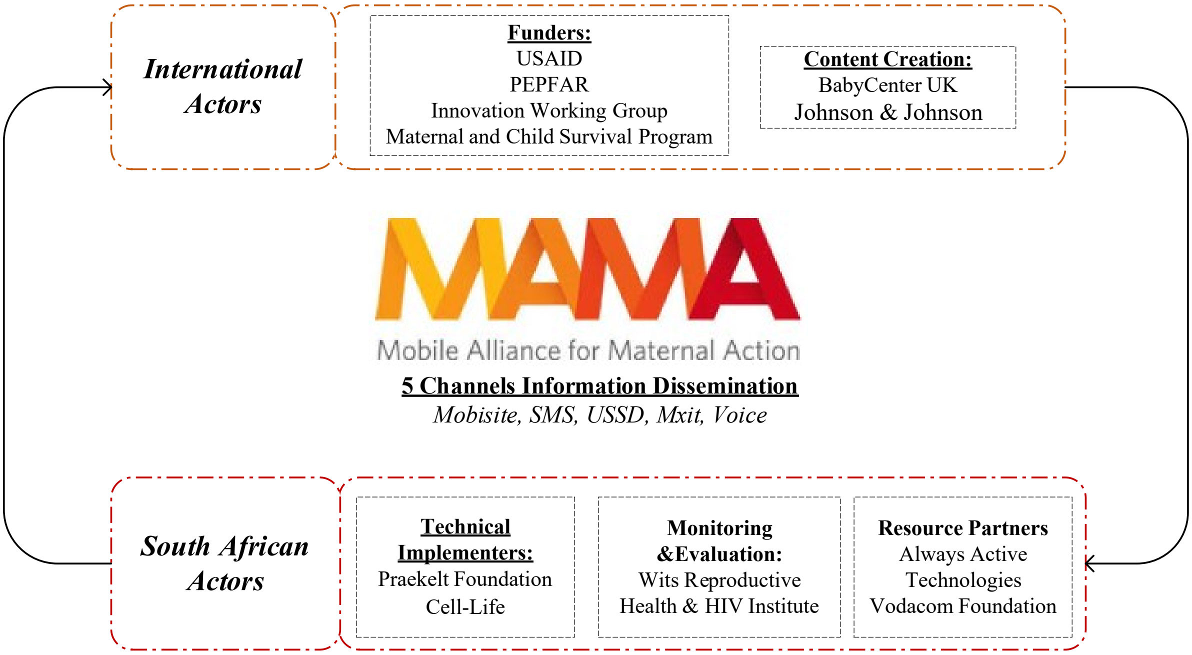

Figure 8.2: MAMA Ecosystem

MAMA SA's inception had a high level of experimentation where there was still testing of what works and what doesn't. Though MAMA SA had learnings from other country implementations [**F2-KDev, F3-KDif**], the business model conceptualisation was a complicated process. MAMA SA had to go through the process of educating the users on the benefits of using the platform [**F5-MF**]. At first, the costs were meant to be covered by the users through sign-ups and interactions on the platform, but the lack of signups made it apparent that the service had to be free for users [**F4-GS, F5-MF**].

The platform disseminated information across 5 channels. These were voice, SMS, Unstructured Supplementary Service Data (USSD), mobile websites and Mxit (a South African mobile phone-based chat platform)[30] [**F1-ENT**, **F5-MF**]. The percentage of traffic was Text/SMS (3%), Mobisite (72%), Mxit Social network (19%), USSD (6%). It was cross a span of 6 out of the 11 South African national languages: English, Afrikaans, Zulu, Xhosa, Sotho, Tswana (MCSP, 2018). The selection of so many channels was due to South Africa being new to mHealth applications, so it was a period of experimenting and testing [**F1-ENT, F2-KDev**]. The increase in the numbers in the mobisite was due to the constant marketing to raise awareness and drive traffic to the website.

The communication on MAMA was just one-way, pushing messages to the users **[F3-KDif].** Message content was created by BabyCentre UK[31] and customised by MAMA South Africa with support from local maternal health specialists. This is a free repository available to non-profit organisations who

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[30] Mxit was a free instant messaging application developed by Mxit Ltd. in South Africa that ran on over 8,000 devices, including feature phones, Android, BlackBerry, iPhone, iPad, Windows Phone and tablets. It closed shop in 2015 and handed over all intellectual property to The Research Trust.

[31] https://www.babycenter.com/mission-motherhood/messages/

wish to reach pregnant women, mothers and other household members in low-resource areas **[F2-KDev].** There was a high implementation cost of moving from a paper-based system to a computerised one [**F2-KDev**]. As a result, user registrations increased **[F5-MF],** but also led to an increased administrative burden and data errors **[F2-KDev].**

To mitigate costs, the program placed the mobisite on the Vodacom Operator Deck [**F3-KDif, F5-MF, F6-RM**]. This made it free for Vodacom customers. Once the program moved to Vodafone Live! there was constant traffic, engagement and usage [**F2-KDev, F3-KDif**]. But the *quality of engagement* declined as some users were using the service as a free chat service rather than as a source of pregnancy information [**F1-ENT**]. Another advertising channel was putting messages on the Johnsons Baby products. Johnson Baby agreed to sponsor 2000 moms on the SMS channel and signing up mothers at roadshows [**F6-RM**]. There was no formal single way of signing up users to the platform [**F2-KDev**]. Praekelt had won a United Nations IWG catalytic grant and this enabled the distribution of a large amount of this funding to fieldworkers, SMS, USSD, content maintenance, and inventory for marketing purposes. (or just grants) [**F6-RM**]. Figure 8.3 shows the Causal Loop Diagram (CLD) for the birth stage of the MAMA ecosystem narrative, which is extrapolated from key activities and events.

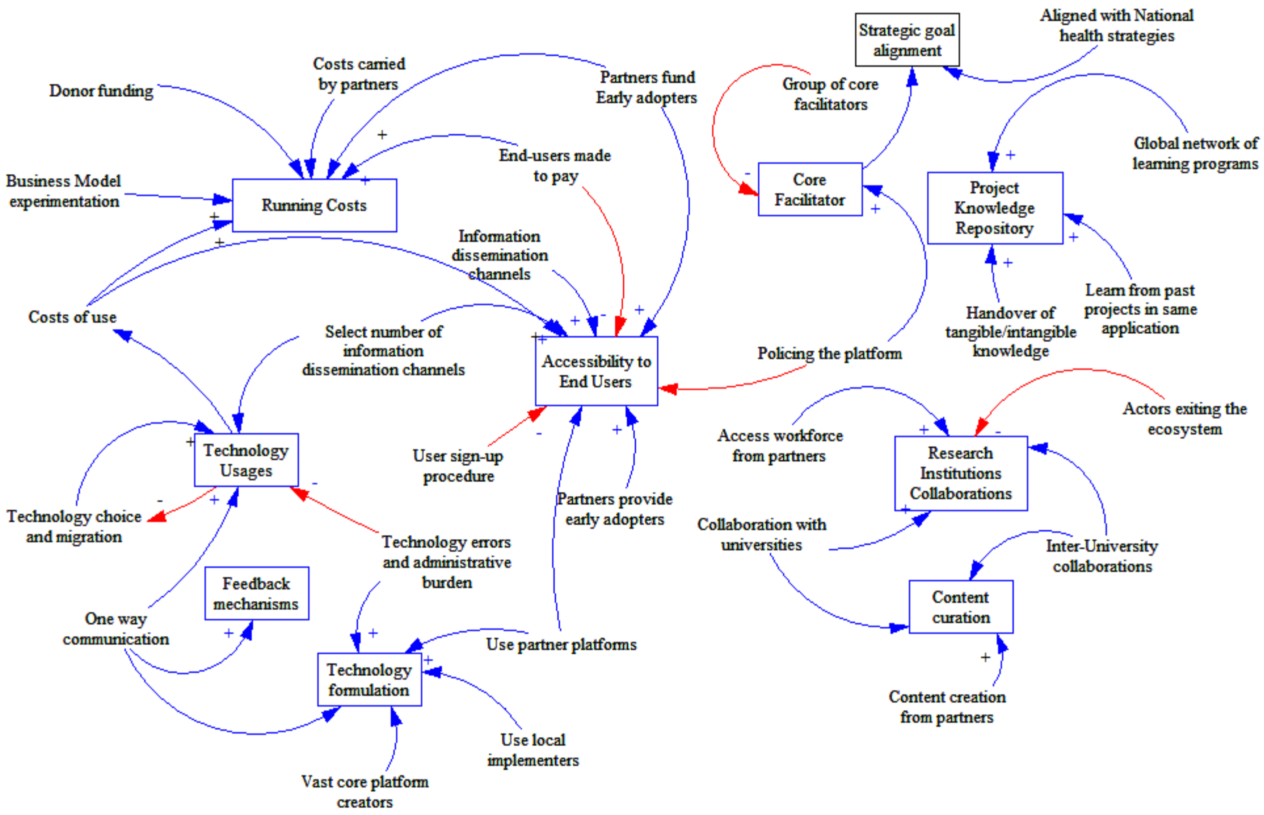

Figure 8.3: MAMA Birth Stage Leverage Points

8.2.2.2 Ecosystem Expansion: 2012-2013

Having many channels to sign up users had various repercussions. It increased the complexity of managing the actors and troubleshooting costs increased, which led to the voice channel being eliminated because of cost of scale due to multiple partner systems involved **[F1-ENT, F6-RM]**. MAMA saw a drop-off rate of 95% in registrations when they required a ZAR0.20 network fee for enrolment [**F2-KDev**]. This was seemingly due to a lack of public trust owing to fraudulent behaviour that had been reported around mobile signup schemes. Hence the service was eventually offered for free across all mobile network operators **[F4-GS, F5-MF].** Moreover, the lack of designated signup gatekeepers also meant that there was no true reflection that only pregnant women signed up to the service **[F1-ENT, F2-KDev, F3-KDif].**

With the service being free, based on a 'pull' not 'push' platform, there was still the question of sustainability. The MAMA implementers carried the cost of the service and tried to enlist corporate sponsors to advertise on the platform as a source of revenue **[F1-ENT, F5-MF, F7-CL].** However, it was found that this required a dedicated team of media sales. There was also a challenge when potential sponsors were also business competitors with any one of the donors **[F6-RM]** and the program team eventually agreed it was not worth the effort[32] **.**

In terms of partnerships, TechChange[33], was brought in to create a series of facilitated online courses as part of the launch of the MAMA Global Learning Program **[F1-ENT, F2-KDev]**. Courses covered a range of topics including how to draft MAMA messages, best practices for localising content, choosing the right technical platform, and were delivered on the TechChange custom online learning platform[34] **[F3-KDif]**. TechChange also produced a video at the 2013 mHealth Summit to capture highlights from the MAMA community and future plans [**F2-KDev**].

Additionally, to adapt and circumvent the exit of Cell-Life-which had been involved in localising content, MAMA hired an employee to spearhead the content adaptation process rather than get another organisational partner **[F2-KDev, F6-RM].** In-house expertise is needed to control the ecosystem evolution and customisation and navigate trade-offs between functionality and cost. Though this is good for sustainability it also closes up the ecosystem [**F2-KDev, F3-KDif**]. Project managers of MAMA SA used an automated online dashboard that provided them with user data and basic analyses of MAMA's different channels **[F2-KDev, F3-KDif]**. The program conducted regular demographic analyses from the programs to assess if it was reaching its intended target audience. MAMA analysts had access to mainly Shanduka Clinic and some Johannesburg inner city clinics through Wits RHI. They conducted interviews with patients and reviewed clinic records besides just relying on the self-reported data **[F2-KDev, F3-KDif]**. Wits RHI[35] also conducted face-to-face exit interviews with SMS subscribers who had completed the SMS program, data was entered by fieldworkers using tools like the Open Data Kit[36] **[F1-ENT]**, which eliminated the need for a separate data entry process. Open Data Kit has now rebranded to an umbrella organisation called Data Software for Social Good which is merging into an ecosystem.

Figure 8.4 shows the CLD for the expansion stage of the MAMA ecosystem narrative, which is extrapolated from key activities and events.

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[32] MAMA full report

[33] https://www.techchange.org/

[34] https://www.techchange.org/work/mama-mobile-alliance-for-maternal-action/2017/

[35] https://www.wrhi.ac.za/

[36] https://opendatakit.org/

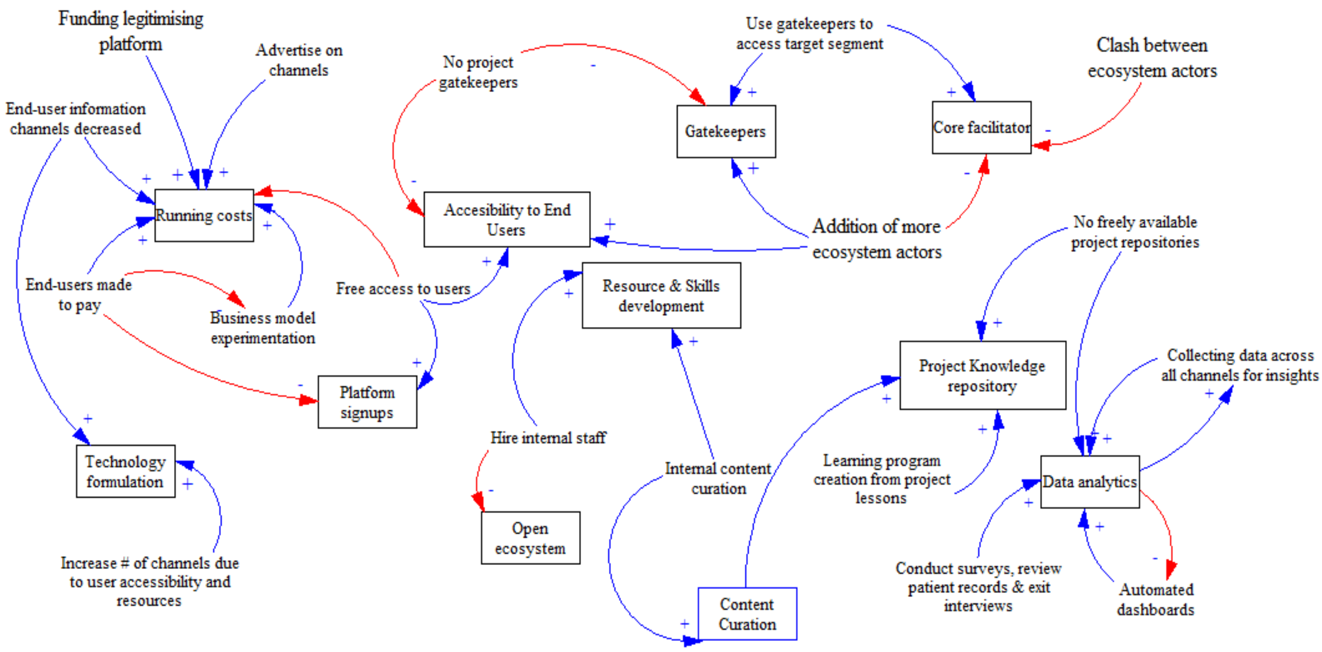

Figure 8.4: MAMA Expansion Stage Leverage Points

8.2.2.3 Ecosystem Self-Renewal: 2014-2015

MAMA realised that not much revenue was forthcoming from advertising and resorted to the strategy of handing over the project to the NDoH. MAMA was handed over to the South African government in 2014 after acquiring about 500 000 users **[F1-ENT, F2-KDev, F3-KDif, F6-RM)** (MCSP, 2018; Peter, Benjamin, LeFevre, *et al.*, 2018). The scale of the program was particularly significant in terms of setting it apart from other implementations of mHealth programs. Autonomy was a bit difficult. If any occurrence happened in the MAMA ecosystem such as actors leaving, e.g. Cell-Life, closing down, this was a reason to draft a new memorandum of understanding with the NDoH (MCSP, 2018)**.** Such bureaucracy would contribute to the slowing down of other ecosystem activities. Such highlights assisted the NDoH in assessing how to streamline some activities and carry on with the initiative.

Lessons learned for the MAMA project over 2010-2016 were evaluated using the mHealth Assessment and Planning for Scale (MAPS) toolkit[37] through a symposium from December 15-16, 2016. Assessment was discussed around the groundwork, partnership, financial health, technology and operations, Monitoring and Evaluation and Content Creation. They then ranked the lessons they thought were most important for successful program implementation and discussed some overarching lessons [**F2-KDev, F3-KDif, F4-GS**]. Some key findings were that creation of multiple channel technology platforms meant that the government had quick responses to roll out national scale with very little adaptation of the technology needed or the need to develop new platforms. These were all aligned to help innovators scale up projects for reproductive and maternal health. This information came in handy when the MAMA program transitioned to the MomConnect under the directive of the NDoH [**F6-RM**].

[37] https://www.who.int/reproductivehealth/topics/mhealth/maps-toolkit/en/

Figure 8.5 shows the CLD for the self-renewal stage of the MAMA ecosystem narrative, which is extrapolated from key activities and events.

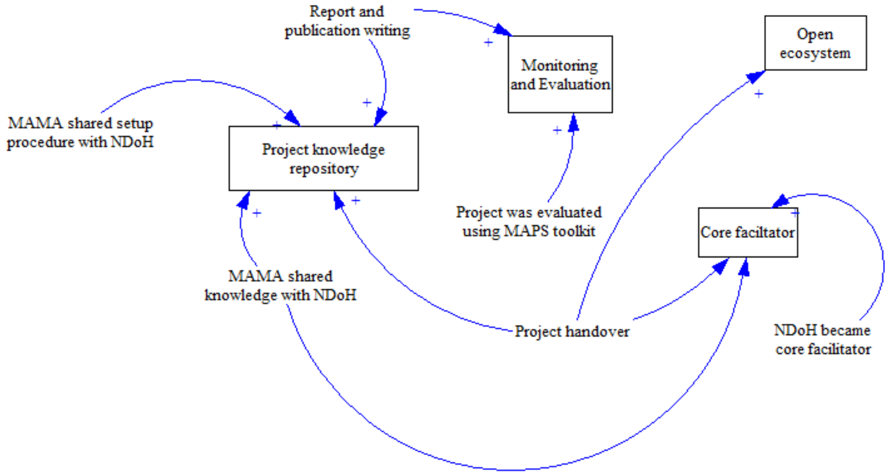

Figure 8.5: MAMA Self-Renewal Stage Leverage Points

8.2.3 MomConnect

8.2.3.1 Ecosystem Birth: 2012-2014

MomConnect was conceptualised in 2012 through a partnership between the United Nations Children's Fund (UNICEF), NDoH, Jembi Health Systems and Praekelt Foundation. MomConnect was launched in 2014 the same year that MAMA was officially handed over to the NDoH [**F4-GS**]. The key intermediary for MomConnect was the NDoH. This was different from other implementations that had external implementers, especially funders, who are located outside South Africa [**F4-GS, F6-RM, F7-CL**]. It had global funders and over 20 collaborating partners [**F6-RM**]. It was an application that was developed on the premise of another mHealth application (MAMA) discussed in the previous sections [**F1-ENT, F2-KDev**].

User signups were via two channels of SMS and USSD **[F5-MF]** and were conducted by nurses and community health workers which also added to their workload **[F3-KDif, F4-GS]**. The messages that were sent to mothers were conceptualised through a collaboration with the Baby Center, which has a repository of resources related to setting up platforms catering for maternal health related projects [**F2-KDev, F3-KDif**]. These also included best practices for setting up text-based helpdesks [**F2-KDev, F3-KDif**]. The Baby Center was also one of the founding partners of the MAMA project. The key pillars of MomConnect are shown in Figure 8.6.

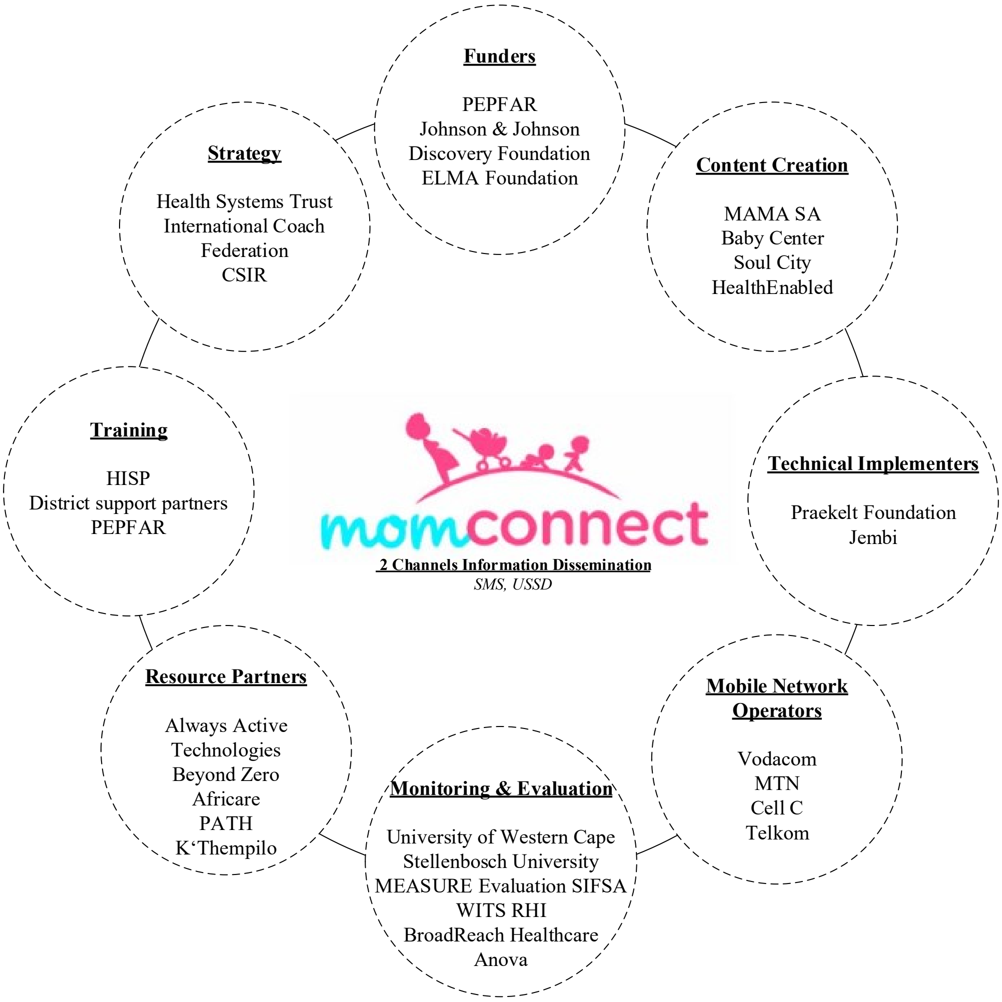

Figure 8.6: MomConnect Key Partners

MomConnect had content disseminated across all 11 local South African languages ensuring to decrease the number of barriers from utilising the platform [**F5-MF**]. The system was connected to over 65% of women in the country across 95% of the clinics[38]. The platform was interconnected to the National pregnancy register administered by the NDoH which connected to other data collection registers [**F2-KDev, F5-RM**]. Interoperability was also promoted through MomConnect partners being part of the Open Health Information Mediator (OpenHIM)[39] project which has accessible frameworks and tutorials on how to mediate based on the Open Health Information Exchange global aligned with open source collaboration to improve interoperability among South Africa's health information systems like DHIS2 [**F2-KDev, F5-MF, F6-RM**]. The NDoH ensured interoperability of the program with the South African Health Information system by ensuring actors involved in implementation were part of the Open Health Information Mediator project. To further educate women on the platform, the NDoH partnered with the national broadcaster and had local drama programs like Soul City incorporate storylines around MomConnect [**F3-KDif, F5-MF, F7-CL**]. Additionally, Facebook was another platform that was utilised for informing users about MomConnect through partner Facebook pages [**F1-ENT**]. Figure 8.7 shows the CLD for the birth stage of the MomConnect ecosystem narrative; itis extrapolated from key activities and events.

[38] http://www.health.gov.za/index.php/mom-connect

[39] https://ohie.org/project/openhim/

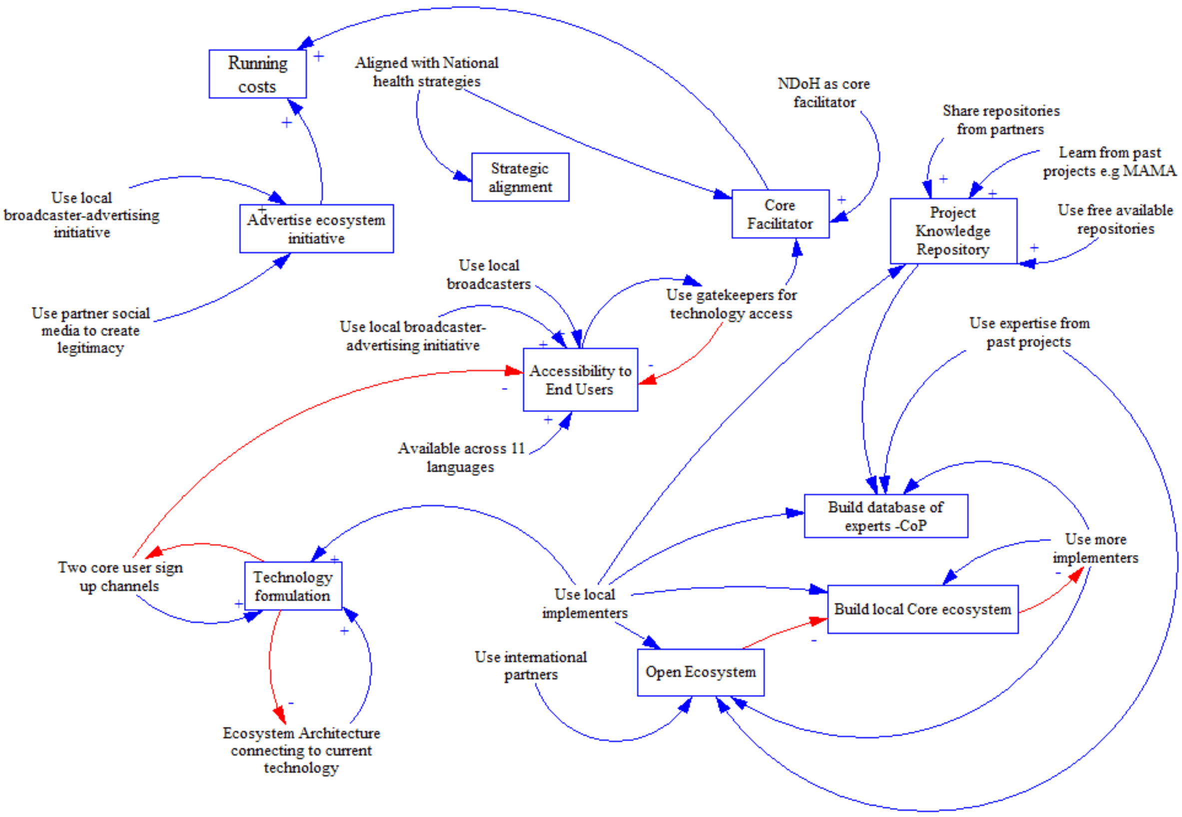

Figure 8.7: MomConnect Birth Stage Leverage Points

8.2.3.2 Ecosystem Expansion: 2012-2017

MomConnect grew in various ways. In 2016, with a sustained growth of more than 1 million users, Praekelt began to experiment with the integration of WeChat[40] and Facebook Messenger messaging apps [**F1-ENT**]. Messaging apps presented an opportunity to expand impact by reducing MomConnect's messaging costs and improving helpdesk efficiency with faster responses and richer, more powerful multimedia content.. However, WeChat was not widely used in South Africa at the time and most of those using the app fell outside MomConnect's low-income target demographic [**F5-MF**]. Integrating with Facebook Messenger presented additional monitoring and evaluation challenges. MomConnect users registered with a phone number via USSD, but most Facebook Messenger accounts are not mandated to sign up with associated phone numbers. This made it difficult for MomConnect to automatically look up and connect Facebook Messenger accounts to its users' MomConnect accounts. Usage of Facebook outside of urban areas in South Africa was also still low in 2016. The data privacy issues as well were considered important when selecting a platform, for example, on Facebook, adverts might be pushed to users due to their user behaviour and this might result in exposing sensitive information such as their HIV status [**F7-CL**]. WhatsApp became a likely option as it offered the widespread use and privacy protections that MomConnect required. WhatsApp accounts could be identified by phone numbers, making linkage to MomConnect accounts easier. Though WhatsApp lacked a public API for integration, Praekelt was invited to

[40] https://www.wechat.com/en/

participate in a private program to pilot WhatsApp's unreleased server-to-server integration which assisted in the learning process [**F1-ENT, F2-KDev, F3-KDif, F6-RM**].

In December 2017, an interaction channel was launched on the WhatsApp enterprise solution [**F1-ENT, F2-KDev, F3-KDif**]. This had been as a result of seeing that there has been an increase of relatively cheap data packages aligned with WhatsApp, smartphone penetration, uptake increase and low data consumption **[F5-MF]**. Initially the service was free but with moving to other platforms that allow for adverts then there can be some form of advertising and data analytics that can be implemented and pushed through [**F1-ENT, F6-RM, F7-CL**]. MomConnect started off with just two channels but now increased the channels. The increase in the number of interactive/interaction platforms that are available amongst users affected the level of responsiveness and resources needed to make sure that the interactions are beneficial and data analysis needs that are spread across the platforms [**F2-KDev, F3-KDif**]. However, such expansion for MomConnect enabled two-way communication and the platform had the ability for users to offer feedback via a helpdesk for various issues that included the ease of access of the platform and issues at health centres such as drug stockouts which could be escalated to the NDoH for attention [**F2-KDev**]. Such feedback channels ensured that information was shared in a timely manner and enabled the NDoH to quickly learn from the compliments and complaints on how to improve the system [**F5-MF**].

The program had over 30 partners and integrated with the National Health System backend, hence the data that was entered onto the MomConnect platform was connected to other platforms that are the core of other sectors of the National Health System. These are like the Health Information Systems Program based in Oslo which created the District Health Information System (DHIS2) –a platform used in over 60 Sub Saharan countries. This was a way of introducing standardisation [**F1-ENT, F2-KDev, F3-KDif, F7-CL**]. This ramped up the ecosystem need for tech savvy personnel [**F6-RM**]. Due to the dynamics of MomConnect, looking to access many previously disadvantaged women was of importance. Having the NDoH as the core facilitator increased the uptake of user sign-ups as it was now made mandatory to sign up the pregnancy [**F4-GS, F5-MF**]. This not only created legitimacy for the program but gave access for growth of the platform **[F6-RM, F7-CL]**.

Figure 8.8 shows the CLD for the expansion stage of the MomConnect ecosystem narrative, which is extrapolated from key activities and events.

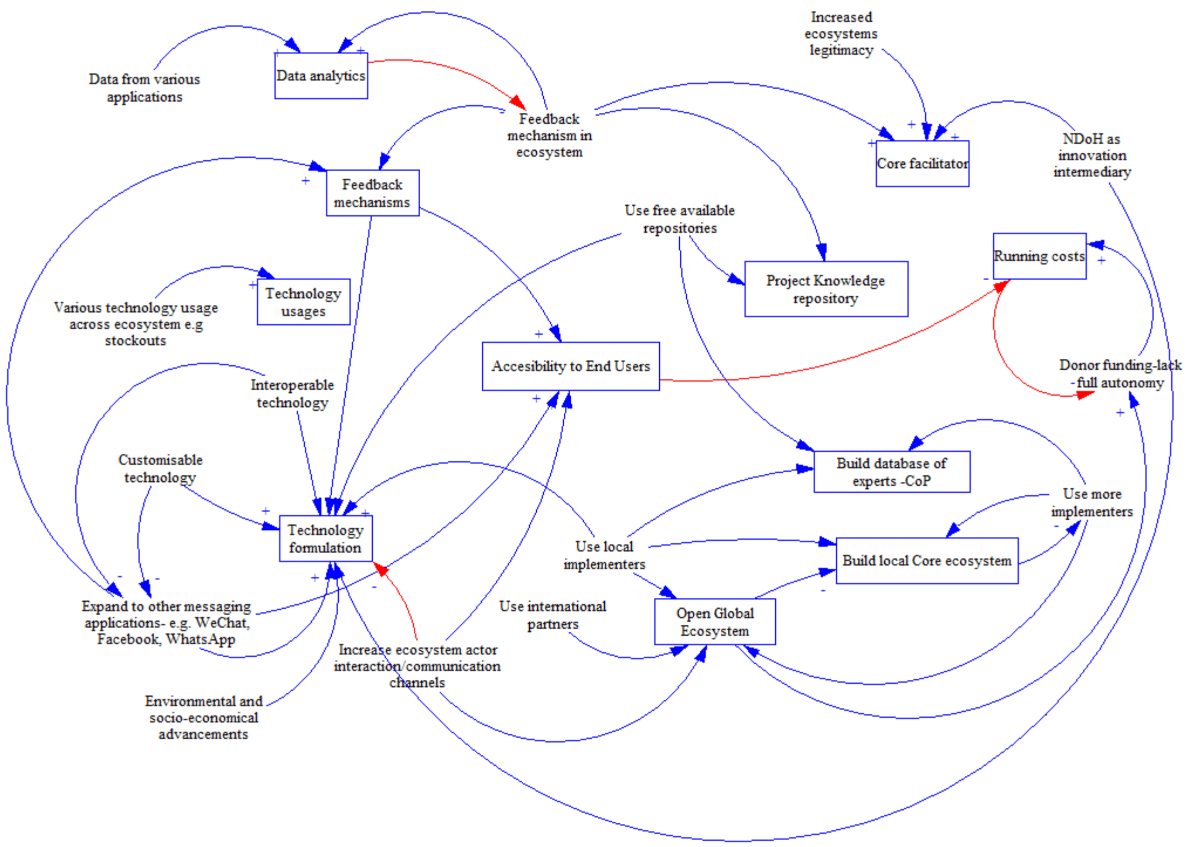

Figure 8.8: MomConnect Expansion Stage Leverage Points

8.2.3.3 Ecosystem Self-Renewal: 2018-Current

Due to the customisability of the platform and the requirements of the ecosystem, various other sub-ecosystems have been formed **[F1-ENT, F2-KDev, F3, F5].** It started with launching an extension of MomConnect called NurseConnect in 2016. NurseConnect was aimed at improving nurses' knowledge of maternal and childcare to improve the level of service delivery and empower nurses [**F3-KDif**]. Additionally, it was aimed at offering psycho-social support to nurses and improve service delivery as the nurses have a place to share information and assist each other. This also gave birth to the conceptualisation of other platforms which are an extension of MomConnect such as ChildConnect[41] - a platform to support early learning for children aged 12 to 18 months. In 2020, HealthConnect[42] a platform which is a customisable platform aimed at the COVID-19 pandemic was also launched based on the same principles as MomConnect. It works through people subscribing to alerts about COVID-19 through SMS or WhatsApp [**F2-KDev, F3-KDif**]. Such agility was also attributed to the fact that one of the South African technology partners was the Praekelt Foundation – a seasoned South African implementer with over 12 years' experience in digital health **[F2-KDev, F3-KDif, F4-GS].** Footprint-wise, Jembi Systems – the South African content curators and providers are now looking to translate the WhatsApp messages to all the official South African languages [**F2-KDev, F3-KDif**]. Of interest is how there is no core

[41] https://innovationedge.org.za/project/childconnect/

[42] https://www.praekelt.org/healthconnect

repository for the whole project as compared to the MAMA project. Though there are institutional and research related projects and publications being undertaken by students that look at aspects of the platform and data accumulated by the platform, these are dispersed across the different institutions[**F2-KDev, F3-KDif, F6-RM**].

Regionally, there are plans in place to roll out the platform in Nigeria and Uganda, increasing the footprint and lesson learnt[43] [**F7-CL**]. MomConnect and NurseConnect also use the platform networks to identify high-level users and train them as brand ambassadors or mentors to create demand for NurseConnect, facilitate discussions, and assist with registrations[44] [**F3-KDif, F6-RM, F7-CL**]. The undertaking of surveys and interviews resulted in information on incorporating high-level users in the networks as ambassadors that also teach others. By 2018, MomConnect was connected to about 95 percent of health clinics across South Africa. However, due to an influx of data, there has been a backlog on the helpdesk and studies have been looking at using language modelling and question answering techniques to answer generic questions [**F2-KDev, F3-KDif**]. Figure 8.9 shows the CLD for the self-renewal stage of the MomConnect ecosystem narrative, which is extrapolated from key activities and events.

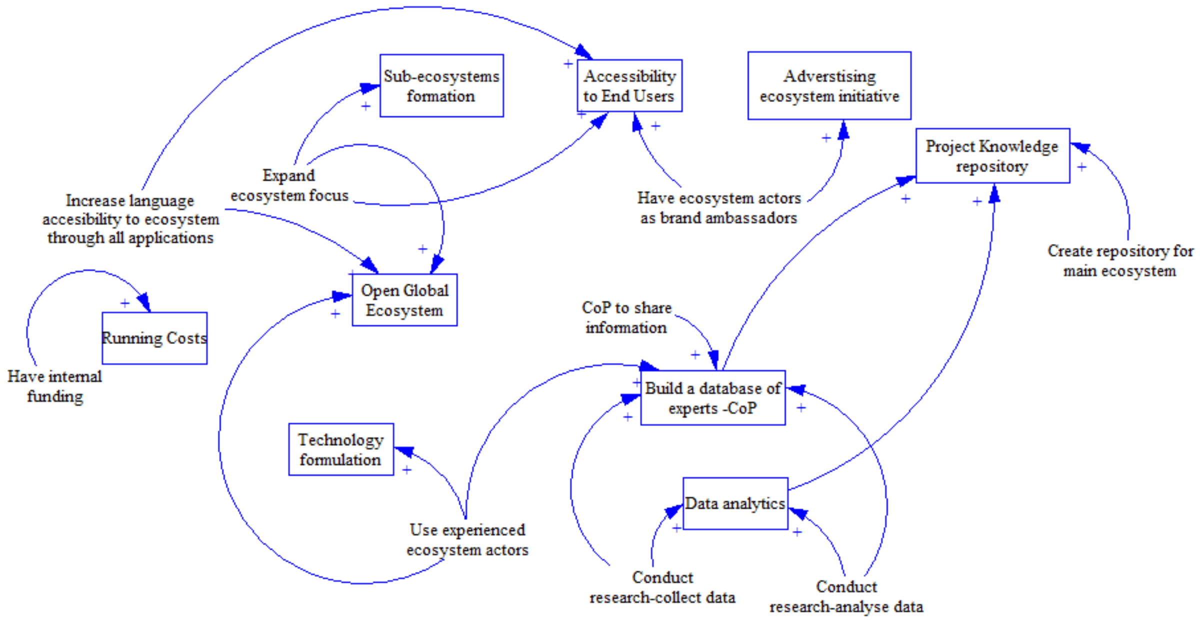

Figure 8.9: MomConnect Self-Renewal Stage Leverage Points

8.3 Reflections on MAMA and MomConnect Framework-mapped leverage points

Though the tool developed in this thesis was still in its preliminary stages without clear understanding of what constitutes leverage points, the framework proved to be useful in assisting with what to look out for in both cases. The previous section outlined the narrative of how MAMA and MomConnect evolved. Figure 8.10 has a depiction of the process.

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[43] https://www.praekelt.org/producthealthstacklearnmore

[44] https://www.bridge.org.za/wp-content/uploads/2019/06/S-by-S-June-11.pdf

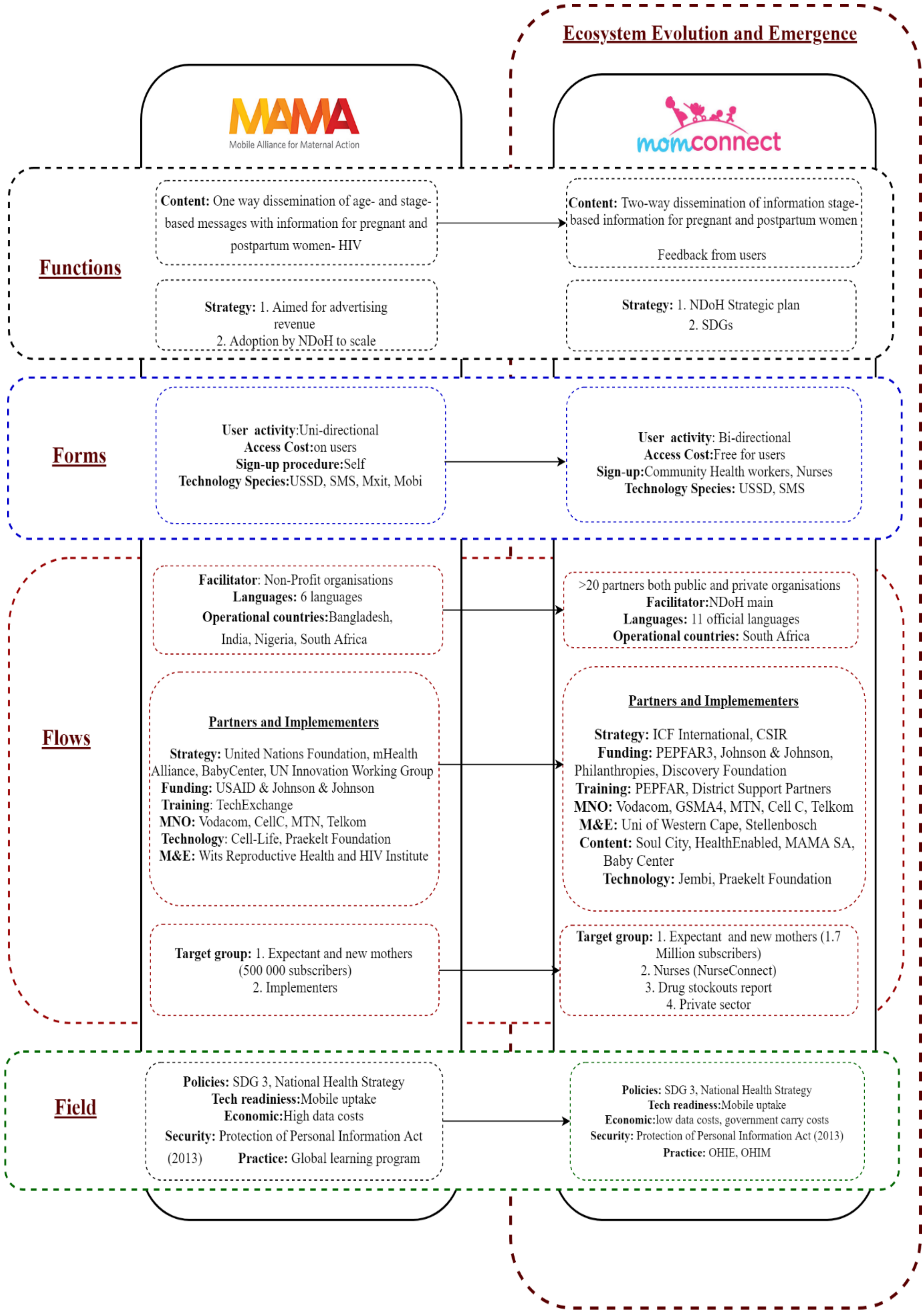
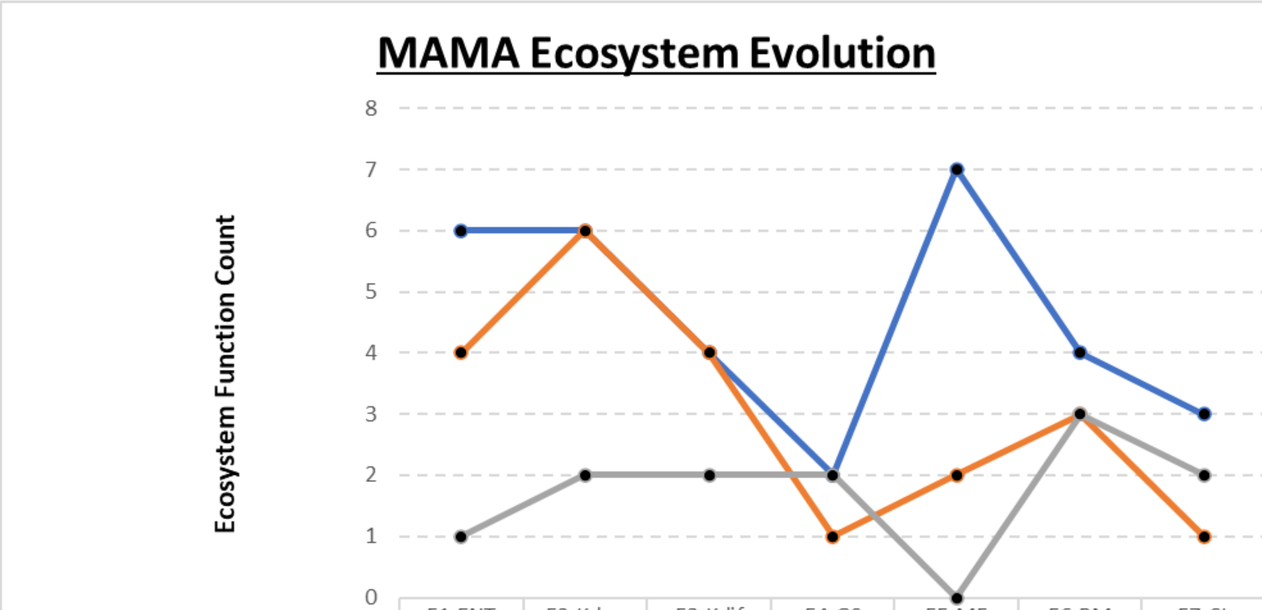


Figure 8.10: Evolution of MAMA to MomConnect

8.3.1 Evolution of Ecosystems Functions

The overall functions that have been identified for MAMA throughout the evolution are shown in Figure 8.11. Of interest is how the narrative depicted what is highlighted in literature when an ecosystem is being created. For example, F1-Entrepreneurial Experimentation is key when it is in the ecosystem birth stage and the activities lessen as the ecosystem is in the self-renewal stage. In the same sentiment, F5-Market Formation are virtually non-existent for MAMA in the self-renewal stage as the ecosystem morphed into another ecosystem. Nevertheless, activities that contribute to functions such as F7-Creation of legitimacy are more or less important throughout the lifecycle of the ecosystem as aspects such as policies are mandatory across all stages of the ecosystem.



	F1-ENT	F2-Kdev	F3-Kdif	F4-GS	F5-MF	F6-RM	F7-CL
Ecosystem Birth	6	6	4	2	7	4	3
Ecosystem Growth	4	6	4	1	2	3	1
Ecosystem Self-Renewal	1	2	2	2	0	3	2

Figure 8.11: MAMA Ecosystem Function Evolution

When comparing MAMA with MomConnect the dynamics also become interesting. Picking the same functions that had been identified previously in the MAMA context, there is identification of stark contrasts. With F1-Entrepreneurial Experimentation, the most activity for MomConnect was during the ecosystem growth phase. In this case this can be based on the fact that the birth of the MomConnect ecosystem had already been established by the MAMA platform. Most of the groundwork had been done in terms of educating prospective users and disseminators of the importance of the platform. Nevertheless, the growth stage needed a lot of experimentation which may explain the rise in the identified F1- Entrepreneurial Experimentation activities.

When it comes to F5-Market Formation and F7-Creation of legitimacy, the markets that were now being formulated were for the other sub-ecosystems that emerged from MomConnect such as NurseConnect, HealthConnect and ChildConnect. Hence having activities around F2-Knowledge development and F3-Knowledge diffusion to assist so many branching sub-ecosystems was important.

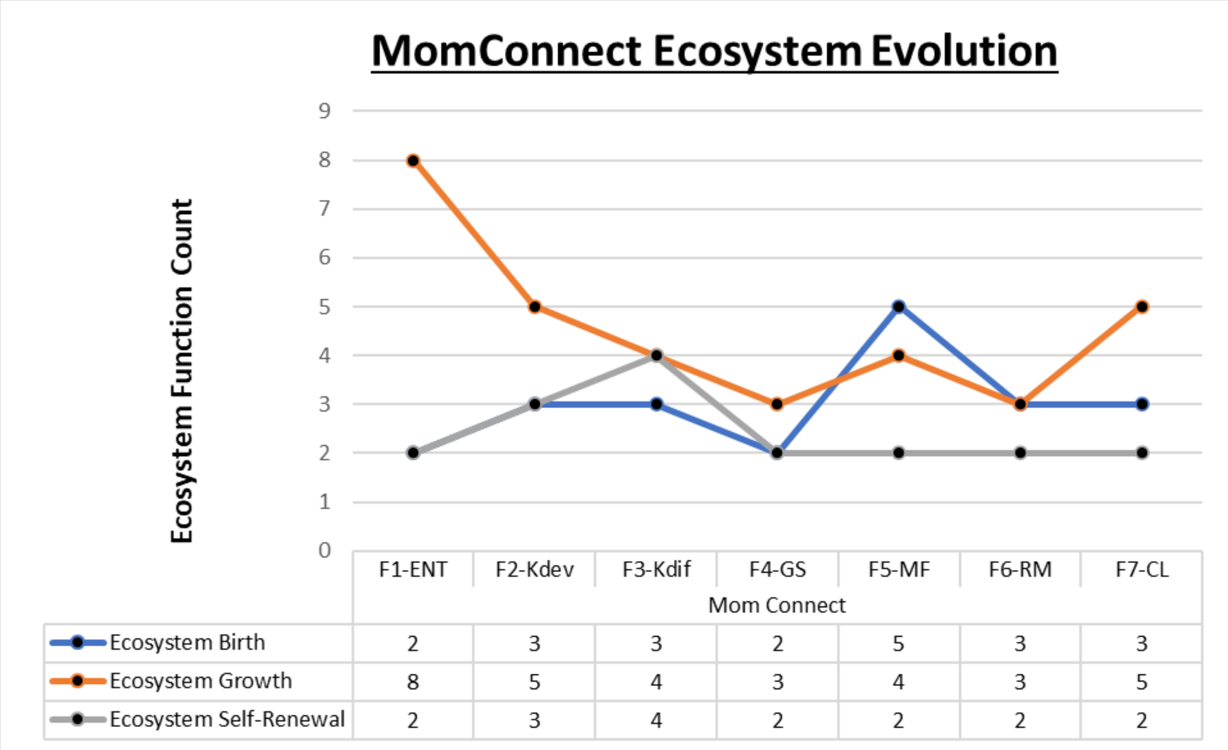


Figure 8.12: MomConnect Ecosystem Function Evolution

Such mapping and comparison of the ecosystem functions was one stage of the analysis of the narratives. The next was to outline the identified leverage points across the functions from the descriptions of the activities. Figure 8.13 aligns the functions comparatively in a diagram.

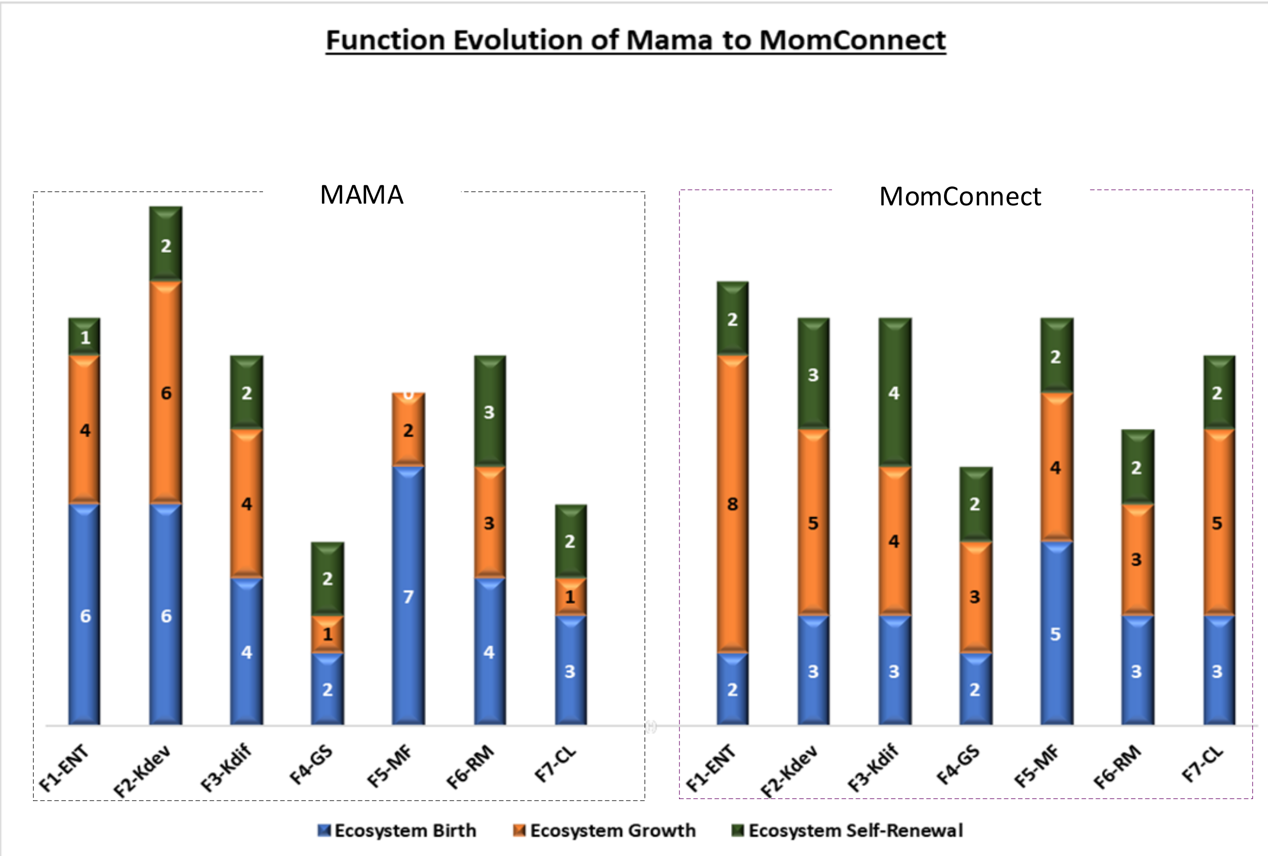


Figure 8.13: Function Evolution of Mama to MomConnect

8.3.2 Identification of Leverage Points and Activities

The mapping process assisted in highlighting the activities that were prevalent in the ecosystem at varying life cycle stages. These were identified in a grouping process elaborated upon in Appendix H and Appendix I. There were leverage points and activities that have occurred to ensure that the ecosystem was able to meet the goals that were mandated and set at the inception of the projects. These are shown in Table 8.1.

Table 8.1: Innovation Ecosystem Leverage Points and Activities

Functions (Bergek, Hekkert and Jacobsson, 2008; Hekkert et al., 2007)	**Ecosystem Lifecycle stage**			
	Birth	**Expansion**	**Self-Renewal**	**Identified Key Leverage points** *(that spurred MomConnect)*
Function 1: Entrepreneurial activities and experimentation	• Experimentation with business model • Select optimum channels for information dissemination • Technology Migration – e.g. from paper based to computerised system increase had high implementation costs	• Feedback mechanisms with users • Technology assessment and temporary focus change • Scale down technology • Consider another platform development • Consider gatekeepers for standardisation and network effects	• Consider expanding ecosystem to other subsystems	• *Cost alleviation (Running costs)*: Costs carried by government • *Feedback Mechanisms*: Two way communication with users • *Sub-ecosystems*: creation of new sub-ecosystems
Function 2: Knowledge development	• Research institutions collaborations • Set up collaboration networks • Learn from past projects • Feasibility studies • Plan content creation	• Create a knowledge repository • Conduct surveys and interviews with ecosystem actors • Hire internal staff for sustainability •	• Have automated dashboards and data analytics	• *Interproject Collaboration*: Handover of 'a failed project' to the NDoH
Function 3: Knowledge diffusion	• Leverage off partner and ecosystem social media • Engage and inform about ecosystem through -conferences, workshops, platforms • Utilise free repositories e.g. MAMA Global Learning programs	• Conduct Workshops • Training programs • Television programs	• Share key findings with ecosystem	• *Blended learning*: teach other countries how to conduct the same program- disseminate information across various channels
Function 4: Guidance of the search	• Selection of ecosystem core facilitator • Select how to engage and attract innovation ecosystem actors	• Select how to engage and attract innovation ecosystem actors • Decrease barriers to access -use many languages	• Share key findings with ecosystem	• *Customisation of content*: usage of technology that is accessible to the women. There was incorporation of local languages

Functions (Bergek, Hekkert and Jacobsson, 2008; Hekkert et al., 2007)	Ecosystem Lifecycle stage			
	Birth	**Expansion**	**Self-Renewal**	**Identified Key Leverage points** *(that spurred MomConnect)*
***Function 5*: Market formation**	• Carry costs of platform maintenance • Have a pool of early adopters to quickly test concepts	• Spearheaded by core facilitator • Public educated on sign-up procedures • Have proper ecosystem joining procedures	• Consider a different core facilitator • Consider subsystems	• *Innovation intermediary type*: Change from private organisations to the NDoH
***Function 6*: Resource mobilisation**	• Subsidies, investments • Leverage off ecosystem networks	• More partners involved in the ecosystem • Utilise automated dashboards • Training of more Community Health Workers for proper data collection	• Consider ecosystem actor realignment-joining and disbanding	• *Partner Characteristics*: MomConnect • *Technology focus*: start with main technologies and diversify later
***Function 7:* Creation of legitimacy (Advocacy coalition)**	• Be aware of polices such as aligned with data protection i.e. POPI act • Be part of communities of Practice OpenHIE exchange platform • Improved telecommunications infrastructure • Alternative energy sources to clinics and hospitals • Find ways to for ecosystem actors to legitimise platform through funding		• Build communities of practice • Build knowledge repositories • Lobby for policy amendments aligned with ecosystem growth	• *Select the right innovation intermediary for ecosystem current interests*

Strategies to circumvent this problem include improving knowledge of and access to care, with initiatives such as expanding the role of community health workers (CHWs) in ward-based outreach teams (WBOTS) to identify and monitor pregnant women, monitor use of the MomConnect antenatal messaging service and providing maternity waiting areas for women who live far from delivery facilities.

8.3.3 Intermediation Activities from MAMA and MomConnect:

The facilitation of the ecosystems played a key role in how they evolved. The distinct difference is MAMA was facilitated by a group of non-South African non-profit organisations whilst MomConnect was facilitated by the NDoH. The overall important roles across the ecosystem life cycle are shown in Table 8.2.

Table 8.2: MAMA and MomConnect Innovation Intermediary Roles

	MAMA	MomConnect	Ecosystem Evolution Effect
Intermediary Type	Non-Private organisations	National Department of Health	*MAMA* - slow growth *MomConnect* -increased network effects ***Key Finding***: Type of Innovation intermediary affects rate of growth of the ecosystem

<table>
<tr><th></th><th>MAMA</th><th>MomConnect</th><th>Ecosystem Evolution Effect</th></tr>
<tr><td>Intermediary roles</td><td><u>Ecosystem Birth</u>
Facilitation:
• Validation and regulation resources;
• Organisational development
• Communications development
• Identification of needs
• Research
• Negotiation

Configuring:
• Technical tinkering
• Co-designing
• Foresight and diagnostics
• Scanning and information processing
• Testing and validation
• Developing work practices
• Training
• Implementing</td><td><u>Ecosystem Birth</u>
Facilitation:
• Evaluation of outcomes
• Accreditation-Formulation of OpenHIE

Configuring:
• Technical tinkering
• Foresight and diagnostics
• Scanning and information processing
• Testing and validation
• Developing work practices
• Training
• Implementing

Brokering:

• Education; links to external info</td><td>MAMA – knowledge accumulation
High resource investment in technology
MomConnect – noted from MAMA what aspects were missing in the ecosystem and worked on them
Key Finding: Knowledge sharing helps in resource constrained environments</td></tr>
<tr><td>Intermediary roles</td><td><u>Ecosystem Expansion</u>
Brokering:
• Advocating
• Knowledge processing and (re)combination
• Gatekeeping
• Protecting the results
• Marketing and Sales
• Customer Service
• Education; Scaling through global learning</td><td><u>Ecosystem Expansion</u>
Brokering:
• Advocating
• Knowledge processing and (re)combination
• Gatekeeping
• Protecting the results
• Marketing and Sales
• Customer Service
• Education: Television</td><td>MAMA - online cases for the MAMA global learning centre facilitated online [45] reaching 32 organisations worldwide
MomConnect – Integration into HIS system
Key Finding: MAMA- Free adaptable mobile messages on website, companion learning modules & share-back of content</td></tr>
<tr><td>Intermediary roles</td><td><u>Ecosystem Self-renewal</u>
• Evaluation of outcomes
• Restrategising-aligned with handing over project to the NDoH</td><td><u>Ecosystem Self-renewal</u>
• Evaluation of outcomes
• New audiences e.g. health workers
• Identify gaps-Creation of Additional subsystems
• Consider sharing lessons with other stakeholders</td><td>MAMA – ecosystem evolved to MomConnect
MomConnect -Evolving to NurseConnect
Key finding: Subsystems enable strengthening of the ecosystem</td></tr>
</table>

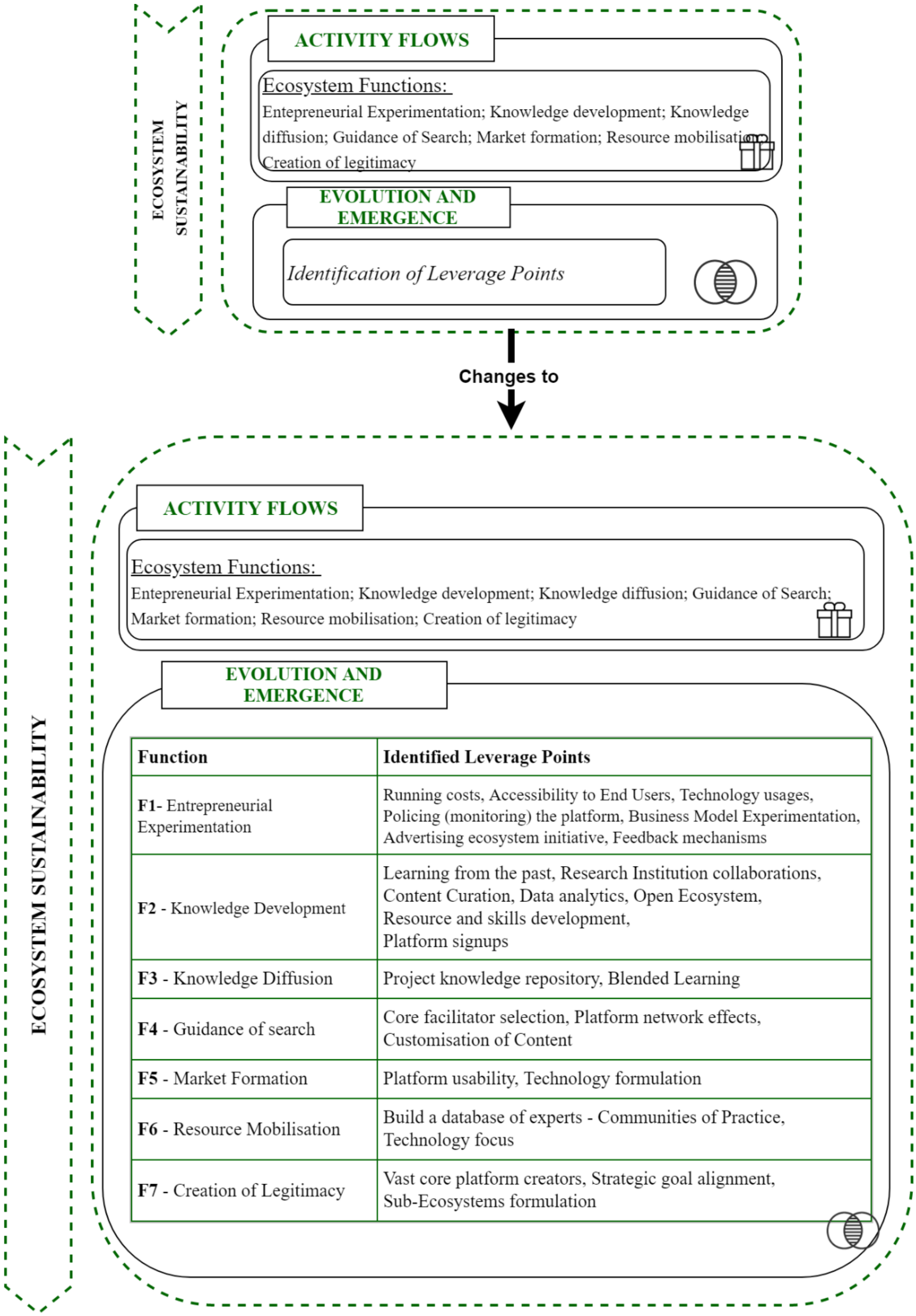
8.4 Amendments to the Framework

The initial state of the framework was only based on the functions and activities which had been identified in literature. After these two cases there were 26 identified leverage points across the 7 functions which are added to the framework. These leverage points are relevant to further enrich the

[45] https://www.techchange.org/work/mama-mobile-alliance-for-maternal-action/

third subsystem of the framework. The listed leverage points were not just the ones on that level, there were the ones uniquely identified as analysis was done from the first to the seventh function. There were cases of the same leverage point being identified for example across most of the functions. The extensive list is in Appendix H and Appendix I.

The amendments to subsystem 3 are shown below in Figure 8.14.



Function	Identified Leverage Points
F1- Entrepreneurial Experimentation	Running costs, Accessibility to End Users, Technology usages, Policing (monitoring) the platform, Business Model Experimentation, Advertising ecosystem initiative, Feedback mechanisms
F2 - Knowledge Development	Learning from the past, Research Institution collaborations, Content Curation, Data analytics, Open Ecosystem, Resource and skills development, Platform signups
F3 - Knowledge Diffusion	Project knowledge repository, Blended Learning
F4 - Guidance of search	Core facilitator selection, Platform network effects, Customisation of Content
F5 - Market Formation	Platform usability, Technology formulation
F6 - Resource Mobilisation	Build a database of experts - Communities of Practice, Technology focus
F7 - Creation of Legitimacy	Vast core platform creators, Strategic goal alignment, Sub-Ecosystems formulation

Figure 8.14: Subsystem 3 Amendments for Leverage points

8.5 Chapter Conclusion

This chapter exemplified how the conceptualised framework can be utilised in assessment of projects that have morphed from each other. Notably, this evaluation of the framework yielded more insight on the structure and characteristics of the activities and leverage points. Nevertheless, for triangulation purposes empirical work was undertaken. This added further amendments to the framework after the analysis of the third case presented in the next chapter

Chapter 9: Secondary Evaluation Process

"*Without change there is no innovation, creativity, or incentive for improvement. Those who initiate change will have a better opportunity to manage the change that is inevitable*." — William Pollard

This chapter presents the third case study of this study which focuses on the District Health Information System (DHIS2). This chapter aligns with the 6th stage of the Soft Systems Methodology which continues from Chapter 8 and is depicted in Figure 9.1. This case was supported by document analysis, scholarly review from the research publications of the DHIS2 ecosystem and two rounds of qualitative interviews with subject matter experts.

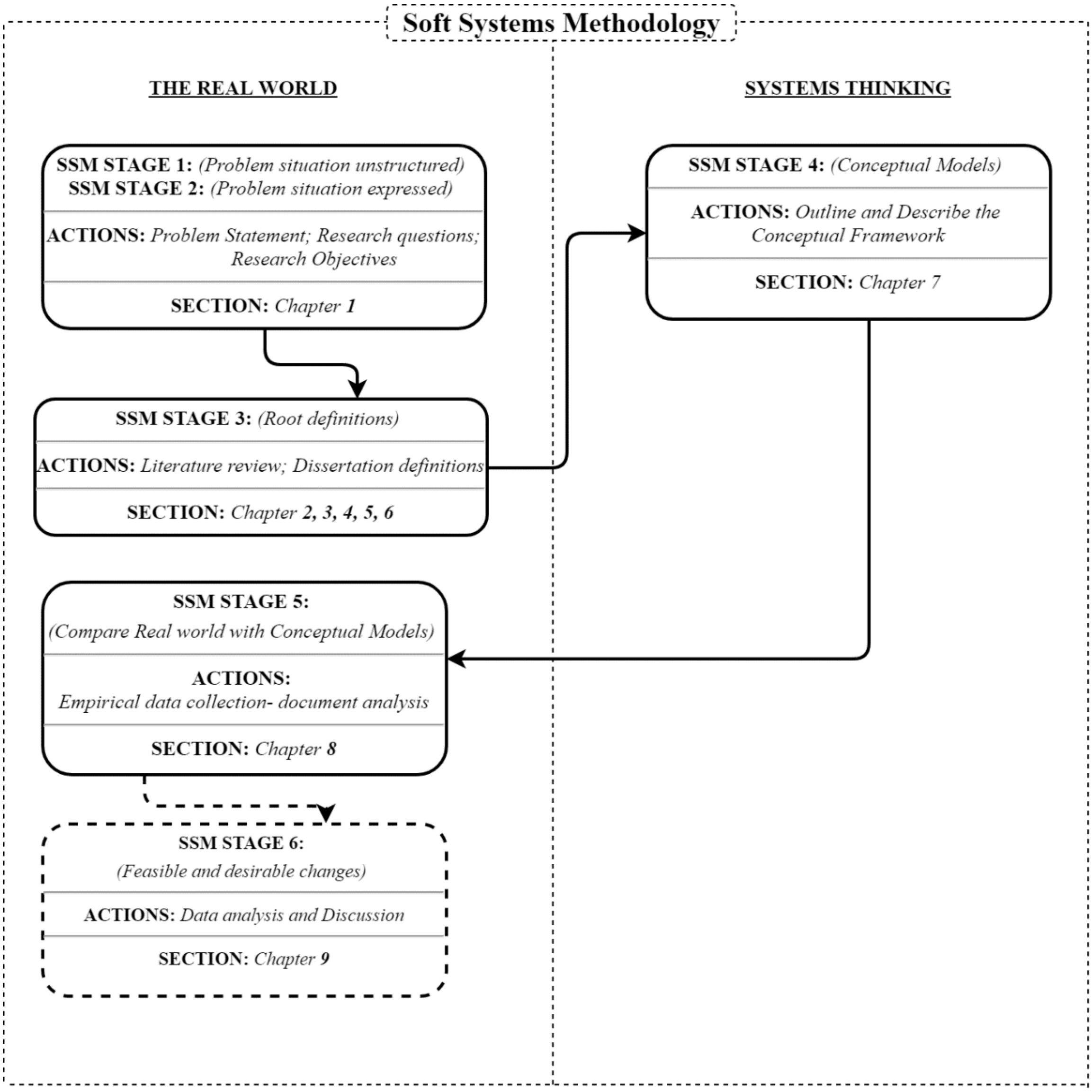


Figure 9.1: The Structure of Chapter 9 within the Context of the Soft Systems Methodology.

In this chapter the Ecosystem Evolution and Emergence Framework was used on the case platform (DHIS2) to further evaluate the framework for practicality. This case was undertaken in three successive ways in order to provide a holistic way to triangulate the leverage points. The mapping of events using ESA through the life cycle stages of DHIS2, a document analysis and semi-structured interviews were concurrently undertaken to inform the framework. The data sources for mapping DHIS2 are outlined in Table 2.6 and a more in-depth overview of the development process is shown in Appendix J and the event database for DHIS2 ecosystem lifecycle stages are in Appendix L.

After the case was completed the overall identified leverage points were categorised and interviews with 3 more subject matter experts were undertaken. These are experts who have worked across different healthcare platforms. The process flow is shown in Figure 9.2.

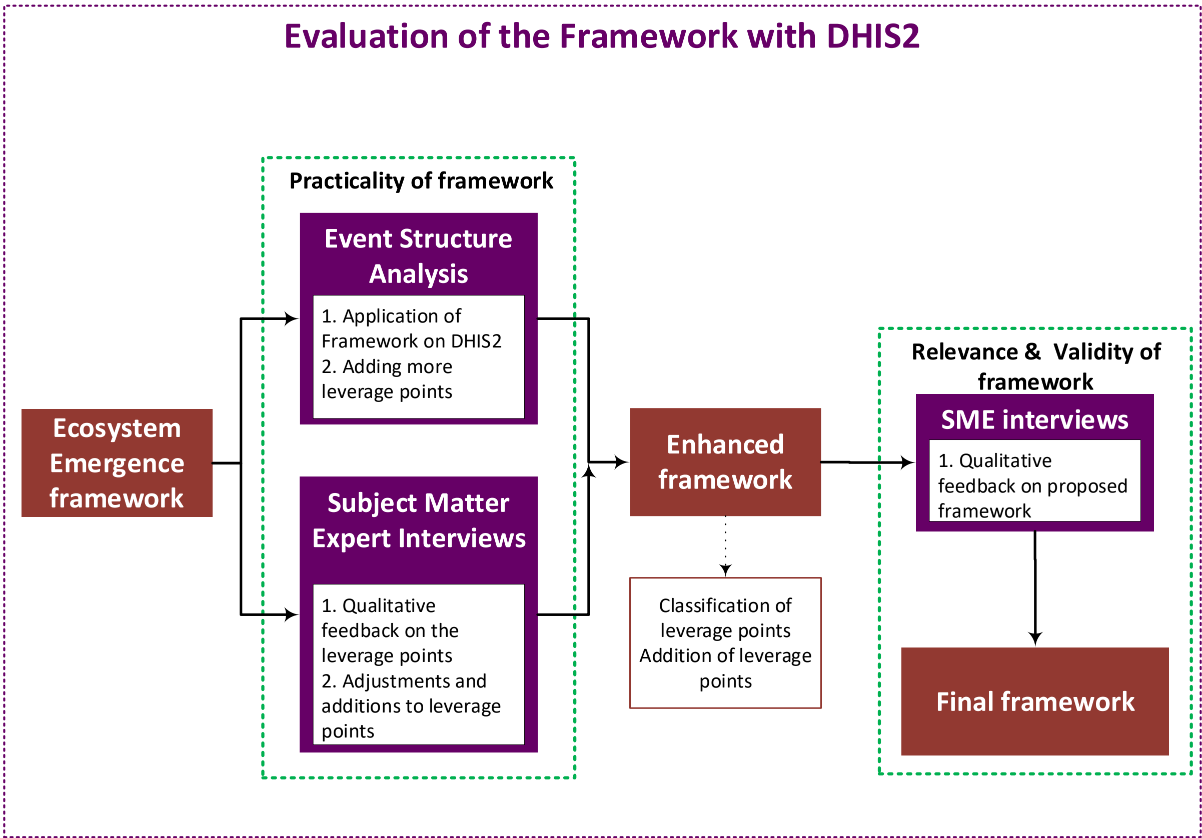


Figure 9.2: Process Flow for DHIS2 Case

As with the previous cases the context of DHIS2 will be outlined first.

9.1 Case Context

The District Health Information System (DHIS2) is a platform that is operational in over 60 countries as a base for the electronic records in developing countries, in particular, Sub-Saharan Africa. The system supports the capturing and aggregation of data varying from routine facility data linked with staffing, equipment, infrastructure to event data aligned with disease outbreaks and longitudinal patient records. DHIS2 comes with purportedly easy to interpret analytics using customised charts, pivot tables, maps and dashboards. It has a web-based portal that facilitates translation into several local languages [46]. It has been utilised in the delivery of various service delivery interventions and in most of the countries the expert knowledge, skills and capabilities for maintaining the platform

[46] https://docs.dhis2.org/2.24/en/implementer/html/ch19s02.html

usually lie outside the health ministries' organisational boundaries. An overview of DHIS2 is shown in Figure 9.3.

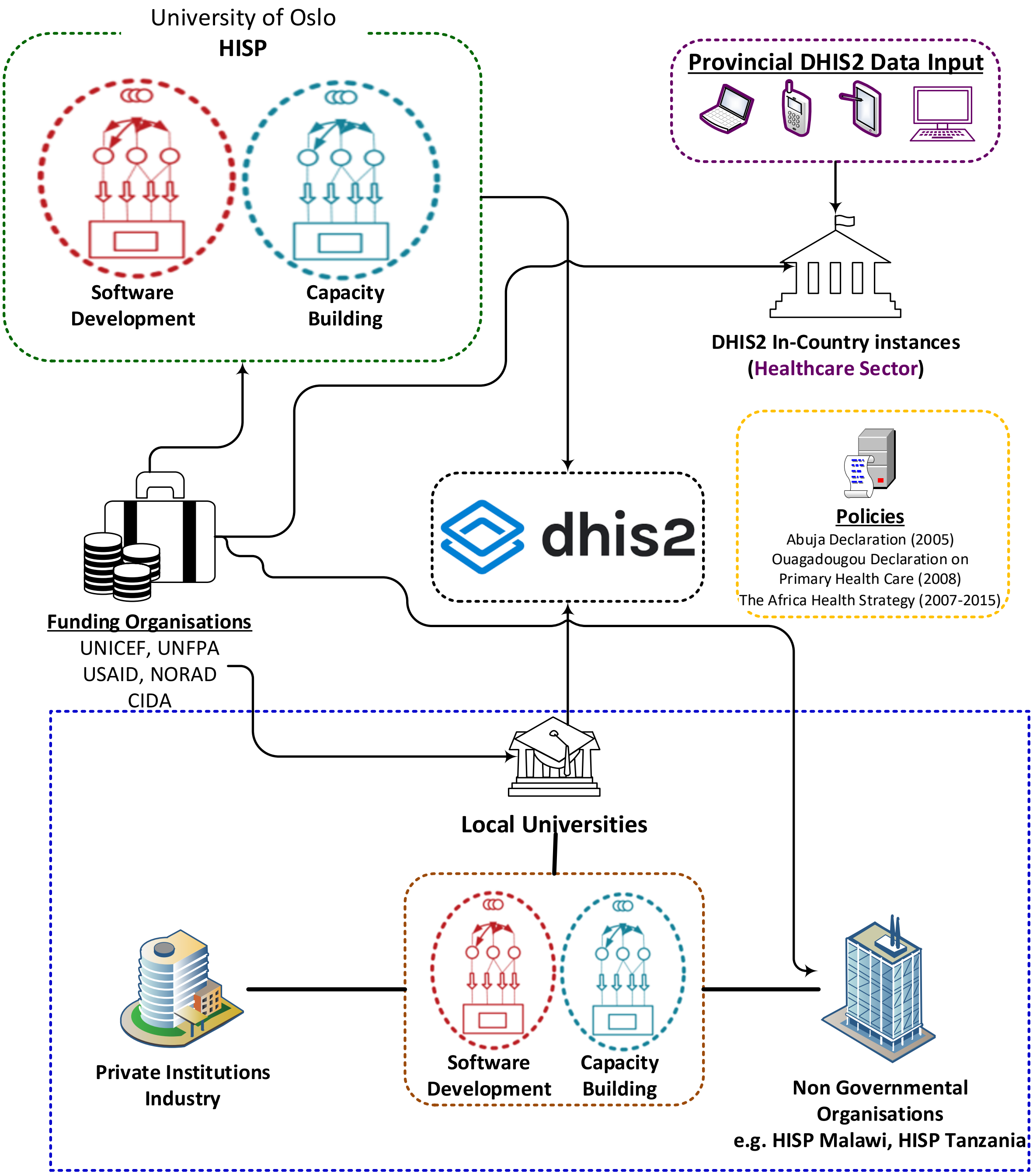


Figure 9.3: Overview of DHIS2

9.1.1 Life Cycle - The District Health Information System (DHIS 2)

9.1.1.1 Ecosystem Birth: 1997-2006

DHIS2 is a software platform that was conceptualised from a doctoral project [**F1-ENT, F2-KDev**] through a collaboration between the University of Oslo (UiO) and the University of Cape Town in 1997 (Braa, 1997) under the Health Information Systems Program (HISP) [**F2-KDev, F6-RM, F7-CL**]. It was launched as DHIS1. It was aimed at to addressing the racial disparities that had been created by apartheid across the service delivery sector through the creation of technological platforms that can assist the healthcare sector through the creation of a consolidated database (Braa, 1997) [**F5-MF, F7-CL**]. This resulted in the core hub of the platform to be developed in the Department of

Informatics at the UiO under the Health Information Systems Program (HISP)[47] [**F5-MF, F6-RM, F7-CL**]. The main funders of the program were the Norwegian Agency for Development Cooperation (NORAD), President's Emergency Plan for AIDS Relief (PEPFAR), The Global Fund, The United Nations Children's Fund (UNICEF) and the UiO shown in Figure 1.2 [48] [**F6-RM, F7-CL**].

The DHIS version 1 was developed using Microsoft Access as a backend database, VBA for the frontend interface, Excel for reporting and Windows as the operating system (Braa, 1997) [**F1-ENT, F2-KDev, F3-KDif**]. It was mainly centralised and a standalone application that collected data that was entered by community health workers and nurses at the district level [**F1-ENT**]. In 2000 DHIS1 pilots were launched in India, Mozambique and Malawi [**F2-KDev, F3-KDev, F6-RM**]. These were improved instances of the pilot version of the platform. A master's programme and the involvement of PhD students became a way of scaling HISP and this saw students implementing DHIS versions in various countries as both study and implementation cases. The program was a way of increasing network effects of the platform Through collaborative networks, partnerships, and action research, this saw different cases iof DHIS instantiated at various levels in different countries [**F2-KDev, F3-KDif**, **F4-GS, F5-MF, F6-RM. F7-CL**]. This was all proprietary software under Microsoft. In 2004, development of DHIS2 started with a shift towards open source technologies [**F2-KDev**, **F5-MF, F6-RM**]. Figure 9.4 shows the CLD for birth stage of the DHIS2 ecosystem narrative, which is extrapolated from key activities and events.

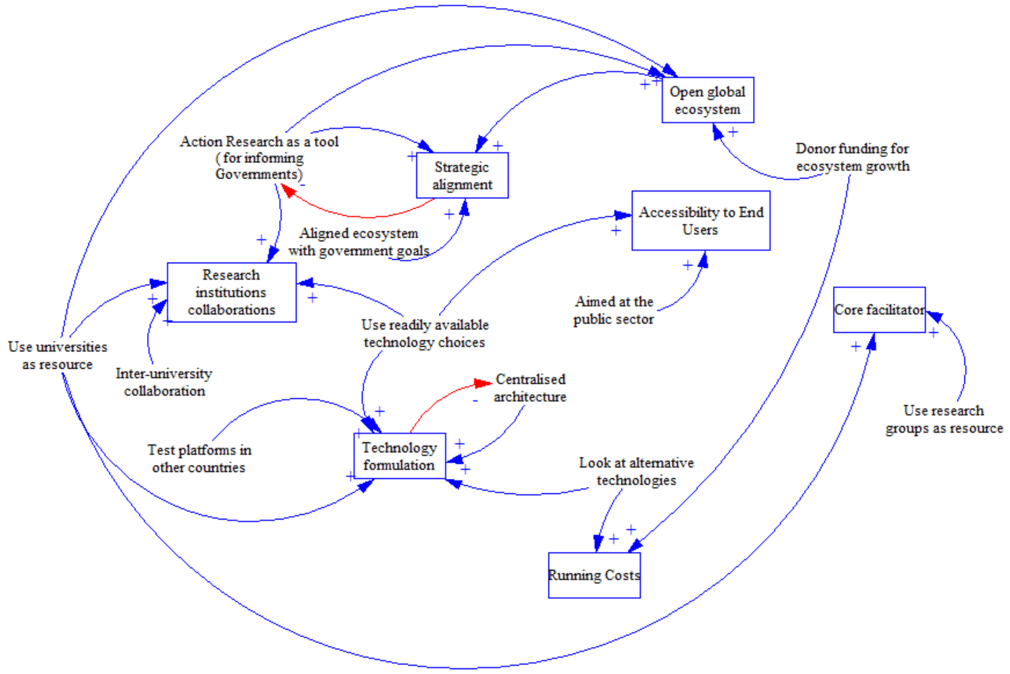


Figure 9.4: DHIS2 Ecosystem Birth Leverage Points

9.1.1.2 Ecosystem Expansion: 2007-2014

In 2006, the first DHIS2 pilot was done in Kerala, India [**F1-ENT, F2-KDif, F7-CL**]. Infrastructurally it had been an alteration of the database and programming language orientation as this resulted in the platform becoming web-based and utilising open-source Java frameworks and

[47] https://www.mn.uio.no/ifi/english/research/networks/hisp/
[48] https://path.azureedge.net/media/documents/DHS_HISP_assessment_final_report.pdf

Android applications support tools [**F2-KDev, F3-KDif**]. Configuration-wise this led to a decentralisation of architecture and a range of flexibility on the local development through improvements that could be done by local developers [**F3-KDif, F5-MF, F6-RM**]. Training events on the software were done yearly at the University of Oslo in Norway [**F2-KDev, F3-KDif**]. In-country training was undertaken at both national and district levels for implementations [**F3-KDif, F6-RM**]. In 2008, another DHIS2 country implementation began in Sierra Leone [**F3-KDif**]. In 2010, there was the first online DHIS2 installation in Kenya and another implementation was done in Punjab, India [**F1-ENT, F2-KDev, F4-GS, F5-MF, F6-RM**]. This also saw the launch of the first regional training event conducted in Tanzania [**F2-KDev, F3-KDif**]. An online user community was started on Launchpad with mailing lists [49]. The DHIS2 mobile was started to reach more communities [**F2-KDev, F3-KDif, F5-MF, F6-RM**] and a messaging function was added inside DHIS2 [**F2-KDev, F3-KDif, F5-MF**]. On the learning side, the first East Africa, West Africa and Asia academies were launched [**F2-KDev, F3-KDif**]. This training was funded by governments [**F6-RM, F7-CL**]. This increased the training that was now happening although the main academy was still being held in Oslo. By 2014 this saw over 10 academies being held and the platform being used in over 46 countries by ministries or other organisations as it was an open source software [**F6-RM, F7-CL**]. This gave the spur to nodes of HISP in-country in other countries like HISP South Africa[50], HISP Tanzania[51], HISP Malawi, HISP Zimbabwe [**F2-KDev, F3-KDif, F4-GS, F6-RM, F7-CL**].

Figure 9.5 shows the CLD for the expansion stage of the DHIS2 ecosystem narrative, which is extrapolated from key activities and events.

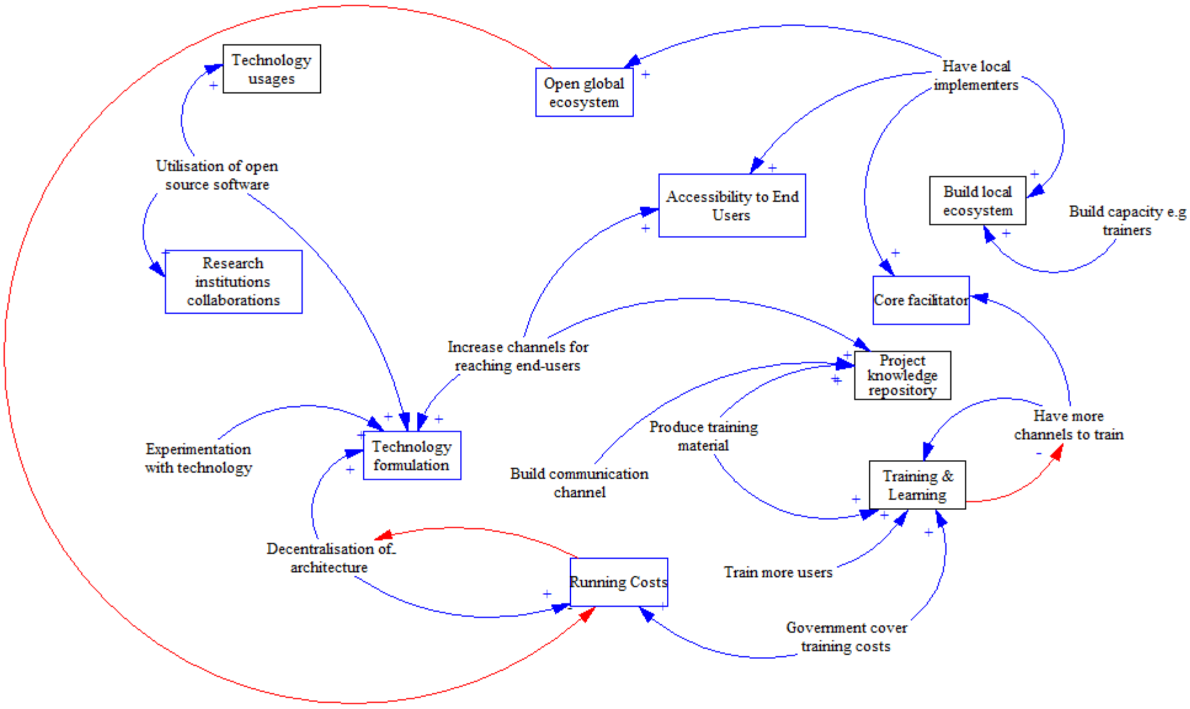


Figure 9.5: DHIS2 Ecosystem Expansion Leverage points

49 https://launchpad.net/~dhis2-devs

50 http://www.hisp.org/

51 https://hisptanzania.org/#/home

9.1.1.3 Ecosystem Self-Renewal: 2015-Current

The evolution of the DHIS2 innovation ecosystem has come from various fronts. Since the technology was now open source, countries and individuals can download and install instances of DHIS2 [**F2-KDev, F3-KDif**]. However, the main development team is still based in Norway. A substantial number of healthcare innovation ecosystems use DHIS2 as an installed base[52] for their platforms and healthcare interventions to address strategic data and information management on disease prevalence. Expansion has also occured around the programming systems as mobile applications are also now being developed on the Android platform and a repository is being kept [**F5-MF, F6-RM**]. This has seen the development of other applications from the hub organisations and in-country customisations such as for Tuberculosis and Malaria [**F1-ENT, F6-RM, F7-CL**]. Hence, the platform spread to over 60 developing countries through action research[53] [**F3-KDif, F5-MF, F6-RM, F7-CL**]. The migration to a web interface and applications in developing countries was also spurred by the first web apps development workshop which was held in Zomba, Malawi. In 2017 the first DHIS2 web development academy was held in Dar es Salaam, Tanzania. These trainings were being conducted and undertaken by the in-country HISP branches [**F2-KDev, F3-KDif**]. The community also evolved from using two different platforms (Launchpad and GitHub) to one web-based community of practice [54] and one for developers for official version control of DHIS 2 [**F2-KDev. F3-KDif**]. On the CoP platform, DHIS2 users and developers engage [**F2-KDev, F6-RM, F7-CL**] with various posts and surveys to convey feedback [**F3-KDif, F4-GS, F7-CL**]. In 2017, the Department of Informatics at the UiO under which HISP is was designated as a World Health Organisation (WHO) collaborating centre for innovation and implementation research for health information systems strengthening. DHIS2 is viewed as a surveillance tool; it has also been made available on the WHO website to increase its accessibility. As of today, DHIS2 is considered an international platform with an international standard offering its services to over 1,3 billion and is appraised as one of the most successful global HIS [55]. Figure 9.6 shows the CLD for the self-renewal stage of the DHIS2 ecosystem narrative, which is extrapolated from key activities and events.

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[52] An installed based may consist of hardware, software, information or knowledge with human or non-human actors interacting with it. It is the previous versions and installations of the platform. Hanseth describes the installed base as *"a sort of a living organism that can be cultivated, instead of dead material to be designed"*(Manda, 2015)

[53] https://www.dhis2.org/

[54] https://community.dhis2.org/

[55] https://www.mn.uio.no/ifi/english/research/networks/hisp/

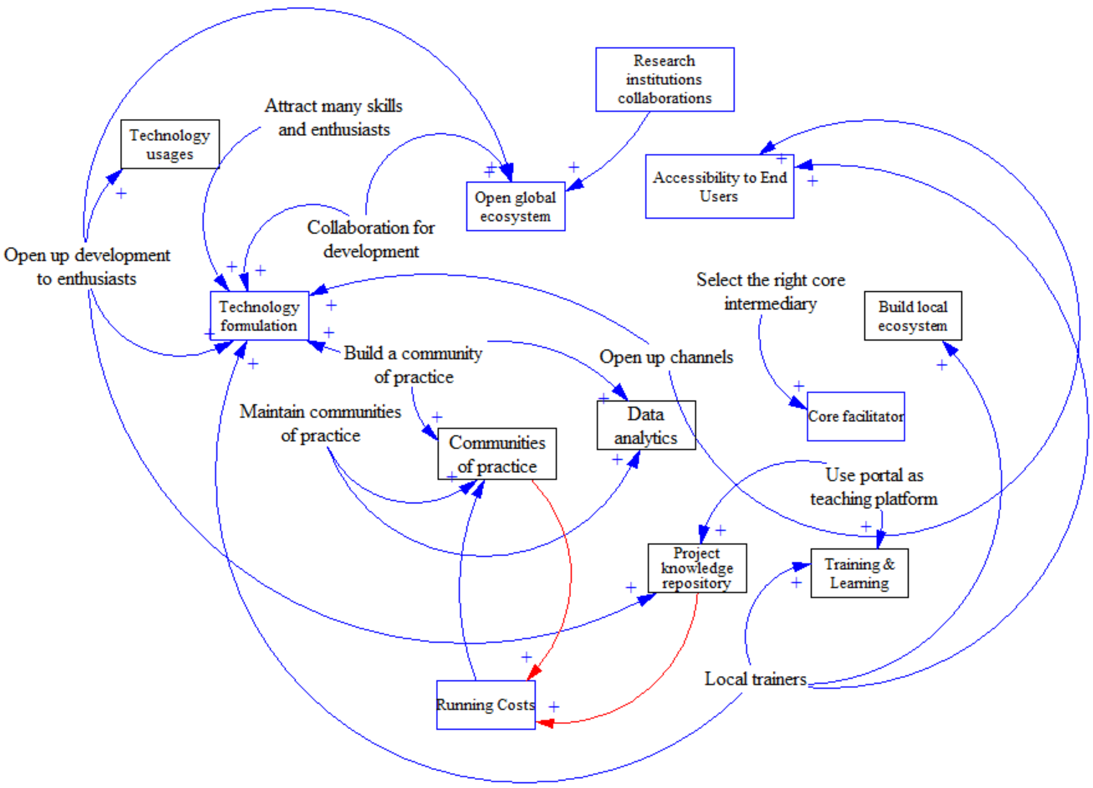

Figure 9.6: DHIS2 Ecosystem Self-Renewal Leverage points

9.1.1.4 Ecosystem Function Evolution

The overall growth in the DHIS2 ecosystem identified from the leverage points from the narratives are summarised in Table 9.1.

Table 9.1: DHIS2 Innovation Ecosystem Activities

Functions (Bergek, Hekkert and Jacobsson, 2008; Hekkert et al., 2007)	**Ecosystem Lifecycle stage Activities**			**Identified Key Leverage points** *(that spurred DHIS2)*
	Birth	**Expansion**	**Self-Renewal**	
Function 1: Entrepreneurial activities and experimentation	• Use universities as resource • Use readily available technology choices • Centralised architecture	• Experimentation with technology • Increase channels for reaching end-users	• Open up development to enthusiast • Build a community of practice	• *Research institutions collaborations* • *Technology formulation* • *Accessibility to End users* • *Technology usages* • *Communities of practice*
Function 2: Knowledge development	• Use universities as resource • Inter-university collaboration • Use readily available technology choices • Test platforms in other countries	• Utilisation of open source software • Produce training material • Increase channels for reaching end-users • Expand to more regions	• Open up development to enthusiast • Open up channels • Build a community of practice	• *Research institutions collaborations* • *Technology formulation* • *Strategic alignment* • *Core facilitator* • *Build local ecosystem*

Functions (Bergek, Hekkert and Jacobsson, 2008; Hekkert et al., 2007)	**Ecosystem Lifecycle stage Activities**			**Identified Key Leverage points** *(that spurred DHIS2)*
	Birth	**Expansion**	**Self-Renewal**	
	• Action Research as a tool • Use universities as resource	• Build communication channel • Increase channels • Train more users • Have local implementers	• Maintain Communities of Practice	• *Open Global ecosystem* • *Training and Learning* • *Accessibility to End users* • *Project knowledge repository* • *Communities of practice* • *Data analytics*
***Function 3*: Knowledge diffusion**	• Use readily available technology choices • Test platforms in other countries • Action Research as a tool	• Experimentation with technology • Utilisation of open source software • Decentralisation of architecture • Produce training material for everyone • Build capacity in-country • Tech experimentation • Conduct training • Build a knowledge repository • Build communication channel • Have more channels to train • Have local implementers	• Open up development to enthusiast • Collaboration for development • Local trainers • Use portal as teaching platform • Maintain Communities of Practice	• *Accessibility to End Users* • *Technology formulation* • *Research institutions collaborations* • *Technology usages* • *Project knowledge repository* • *Build local ecosystem* • *Training and Learning* • *Running costs* • *Communities of practice* • *Data analytics*
***Function 4*: Guidance of the search**	• Use universities as resource • Look at alternative technologies • Action Research as a tool	• Increase channels for reaching end-users • Have local implementers	• Maintain Communities of Practice	• *Running Costs* • *Technology formulation* • *Research institutions collaborations* • *Accessibility to End users* • *Data analytics*
***Function 5*: Market formation**	• Aimed at the public sector • Action Research as a tool for expanding and informing governments	• Decentralisation of architecture to include local developers • Increase channels for reaching end-users • Increase channels • Build communication channel	• Collaboration for development	• *Accessibility to End Users* • *Research institutions collaborations* • *Technology formulation* • *Build local ecosystem* • *Open global ecosystem*

Functions (Bergek, Hekkert and Jacobsson, 2008; Hekkert et al., 2007)	**Ecosystem Lifecycle stage Activities**			**Identified Key Leverage points** *(that spurred DHIS2)*
	Birth	**Expansion**	**Self-Renewal**	
***Function 6*:** Resource mobilisation	• Inter-university collaboration • Use universities as resource • Test platforms in other countries • Action Research as a tool	• Decentralisation of architecture to include local developers • Build capacity in-country • Increase channels • Increase channels for reaching end-users • Government covers costs • Open to everyone • Have local implementers	• Attract many skills and enthusiasts • Open up development to enthusiast • Collaboration for development • Build a community of practice	• *Research institutions collaborations* • *Core facilitator* • *Technology formulation* • *Running costs* • *Build local ecosystem* • *Accessibility to End users* • *Training and learning* • *Open Global ecosystem* • *Running costs* • *Project knowledge repository* •
F7-CL: Creation of legitimacy	• Donor funding for ecosystem growth • Use research groups as resource • Use universities as resource • Look at alternatives • Aligned ecosystem with government goals • Action Research as a tool	• Experimentation with technology • Government covers costs • Open to everyone • Have local implementers	• Open channels • Select the right core intermediary • Open up development to enthusiast • Collaboration for development • Build a community of practice	• *Running costs* • *Open Global ecosystem* • *Core facilitator* • *Technology formulation* • *Strategic alignment* • *Research institutions collaborations* • *Training and learning* • *Accessibility to End Users* • *Open Global ecosystem, Running costs* • *Accessibility to End Users* • *Project knowledge repository*

These cumulative leverage points when mapped in terms of the ecosystem stages are shown in Figure 9.7. Of importance is to note how the creation of legitimacy was important especially in the Self-renewal stage of the ecosystem. This can be attributed to how the learning processes in the ecosystem have changed to be more open across various platforms. This can also explain why the Knowledge development and Knowledge diffusion stages have also more prominent activity in the Self renewal stages of the ecosystem.

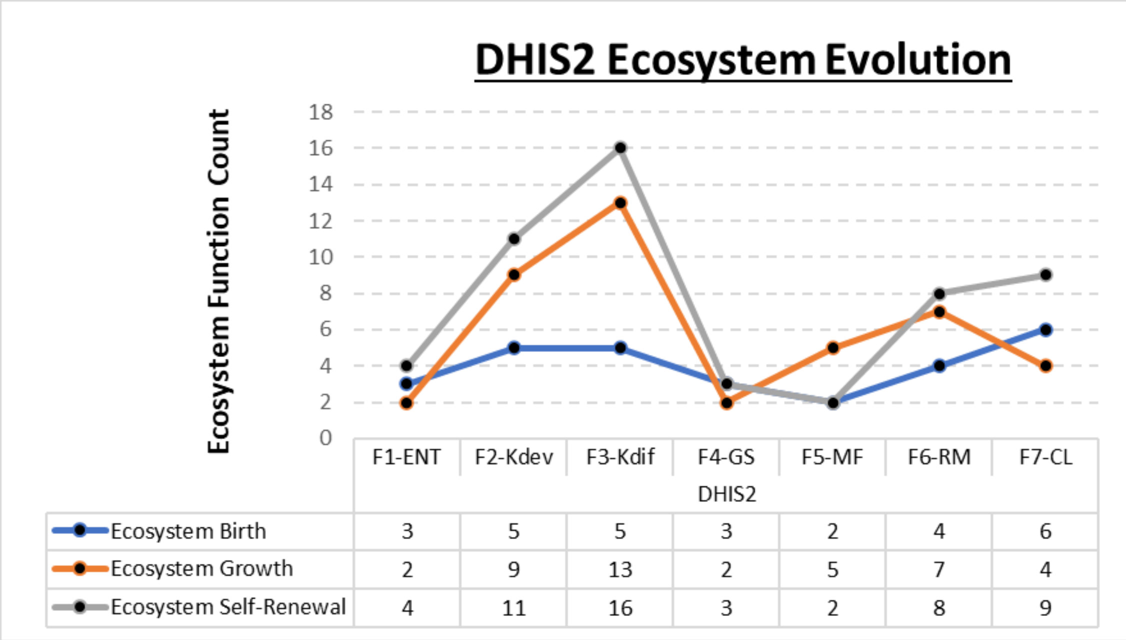

Figure 9.7: DHIS2 Ecosystem Function Evolution

9.1.2 Document Analysis of DHIS2 Scholarly Review

The unique thing about the DHIS2 platform is it was a project under the HISP project housed in the Department of Informatics at the UiO. The network effects of the platform stemmed from action research being undertaken by Bachelors, Master's and PhD-level students under the research and education unit of HISP which has seen a substantial number of training, courses and empirical case studies from research undertaken by the master's and PhD cohorts[56]. In this study this proved to be a valuable data source in the process of identifying leverage points. The review was a systemised meta-synthesis[57] of the publications noting that:

- documents to be reviewed were confined to 3 books, 3 evaluation reports, 27 master's theses and 40 PhD dissertations –produced between 1997 and October 2019. 7 publications were excluded due to restricted access because of the sensitivity of the studies.
- the lens for finding leverage points was identifying key aspects that were being investigated, what the study pointed out as hurdles to implementation, supportive factors and what was recommended for sustainability / continuity.
- classification of the identified leverage points to the seven innovation system functions outlined by Hekkert (2007).

Leverage points in the DHIS2 ecosystem have been mainly both through infrastructural incremental innovations and through the diverse needs in the in-country contexts which affect the next implementations or how DHIS2 carries on. Hence the ecosystem's emergence can be noted to be around leverage points related to functionality that causes the ecosystem to move towards a new

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[56] https://www.mn.uio.no/ifi/english/research/networks/hisp/masters-phd-and-action-research.html

[57] Meta-synthesis is a non-statistical technique used to integrate, evaluate and interpret the findings of multiple qualitative research studies (Cronin et al., 2008; Zimmer, 2006). This entails high level abstraction from isolated and contextually distinct findings from various qualitative studies Meta-synthesis involves analysing and synthesizing key elements of each concept being addressed by the review in order to transform individual findings into conceptualizations and interpretations (Cronin et al., 2008).

direction. Some of the main leverage points in DHIS2 found in the publications include the infrastructure evolutions which has distinct aspects of different activities aligned with it. A table compiled from the full review is found in Appendix L.

The leverage points and activities that were identified are shown in Table 9.2.

Table 9.2: Leverage Points from DHIS2 Related Publications

Leverage point	Ecosystem Activity	Example ecosystem Activity
Infrastructure evolution	Technology arrangements/ Architectural approaches	• Migration from DHIS 1 to DHIS2
	Platform development	• GIS integration
	Application development	• Offline training app • Web/based mapping • Tooltips application
	Archetypal situations for design-reality gaps	• League Tables application and integration
Knowledge repository	Capacity building- In country module formulation -	• Build modules aligned with MoH initiatives
	Review of relevance of documentation	• Hands-on training and system experimentations techniques • Usability of online tools • Usability and user documentation
Standardisation	Standards and implementation guidelines	• Integration of scientific knowledge and context specific knowledge to create standards
Learning	Blended learning	• Integrate blended learning e.g. aspects for online trainings
	Interactive learning	• Negotiated order of learning • Learning from each other and other implementations • Different customization sites enabled the emergence of competence-building practices of cross-site interaction, tailored training and collocated learning
	Learning programs with universities	• Capacity strengthening using short courses or Masters and PhD programs
User empowerment	User empowerment	• Community health workers feedback • Elaborates on ways and means of designing and implementing blended learning programs, which are empowering, informal, participatory and equitable
Core Facilitator	Development philosophy	• Understand the development philosophy behind e-government initiatives
Technology Transfer	Guideline development	• Technology translation • Build local capacity and expertise • Create learning climate • Maintain and evolve technology in a manner of value to the ecosystem
	Competence Building	• User preferences • Strategies • Knowledge brokers between health workers and rural areas • Cultivation of mentors
	Work practices	• Analysis of Transformation in the work practices • Work practices as part of building sustainability • Duality of work practices traditional versus

The additional leverage points that were identified from this analysis were *Archetypal design (centralised vs decentralised)*, *Build Local Ecosystem*, *Technology Transfer, Platform development (e.g. frequency of updates), Development philosophy Application development (i.e. complementary applications), Training (Capacity building)*. These additional leverage points were specifically around learning and competence building as more studies focussed on the end-user. These were added to the list formulated in section 8.4.

9.1.3 Semi-Structured Interviews

Considering the identified leverage points and the DHIS2 narratives, the intent was to have subject matter experts (SMEs) of such technological platforms give input to inform the framework and point out the key activities. From this background, interviews were then undertaken with 20 participants who are developers, implementers, evaluators and end-users of DHIS2. The semi-structured interviews were conducted as a mix of face-to-face and virtual interviews utilising the Skype and WhatsApp platforms. Some interview candidates had no Skype profiles hence the alternative of using WhatsApp. All interviews were recorded for transcription purposes. The interview guides (found in Appendix F) was formulated with the primary aims to understand:

1. the existence of such leverage points in the ecosystems they have been involved in
2. what they viewed as the most important leverage points of the DHIS2 ecosystem
3. participation in current identified leverage points or willingness to participate if future activities aligned

The semi-structured nature of the interviews allowed for active engagement regarding the dynamics around the platform. The objective of the semi-structured interviews conducted was to determine where the proposed theory and the practical application are congruent or different to decrease the gap between theory and reality which aligns with the 6th SSM stage. The interviewees were selected to represent a holistic picture and diverse viewpoints, experiences and groups of people that relate to the usage and management of the DHIS2 ecosystem. The interviewee profiles are shown in Table 9.3. Some interviewees had cross profiles of being at one stage end-users and then became facilitators or implementers. The identity of the interviewees was anonymous.

Table 9.3: DHIS2 Subject Matter Experts Interview Participant Profiles

SME no.	Interviewee Profile	Affiliation	DHIS2 experience
1	Core member of the HISP research program	HISP Oslo	16
2	Platform strategist	HISP Oslo	12
3	PhD alumni, DHIS application dev and support entrepreneur	ITINordic Zimbabwe	9
4	PhD alumni, Lecturer University of Malawi, DHIS application dev and support entrepreneur	Chancellor College, University of Malawi, HISP Malawi	12
5	M&E Specialist	NGO Uganda	4
6	Deputy Director HISP Malawi	CMED Malawi, HISP Malawi	10
7	MSc Student, DHIS Developer and researcher	Worked for MSF, Ministry of Health Malawi	7
8	Developer and Implementer of National MIS	Chancellor College, University of Malawi	4
9	MSc Student, DHIS Developer	Chancellor College, University of Malawi, HISP Malawi	3
10	Implementer & Trainer	Baobab Health Trust - Malawi	5
11	HMIS officer - end user that utilises platform in work procedures	Ministry of Health Malawi	4
12	HMIS officer - end user that utilises platform in work procedures	Ministry of Health Malawi	9

SME no.	Interviewee Profile	Affiliation	DHIS2 experience
13	HMIS officer - end user that utilises platform in work procedures	Ministry of Health Malawi	6
14	Implementer & Trainer	CMED Malawi, HISP Malawi	11
15	M&E Specialist	Global Fund-Zimbabwe	8
16	Implementer and Developer	DeLorr Services	8
17	Strategist, Manager, Trainer and Implementer	Baobab Health Trust-Malawi	14
18	Implementer & Trainer	ITINordic Zimbabwe	4
19	MSc Student, DHIS Developer	Chancellor College, University of Malawi	3
20	Implementer & Trainer	ITINordic Zimbabwe	3

Quality was maintained throughout the interview process by standardising the data collection process through a systemised six-step process. The first step was to obtain consent from the interviewee for participating in the interview and to be made aware that the interview is being recorded for data collection purposes. This was followed by a short overview of the project background. The interview outline was then described to the interviewee. Subsequently, the interview questions were asked while adhering to the interview outline and asking probing questions. The fifth step entailed the interviewee asking any questions or highlighting any concerns regarding the discussion points. The final step was transcription of the interviews into MS Excel where they could be analysed and coded. The approach to the data analysis is discussed in the next section.

9.2 Interview Results and Discussions

The data analysis followed the steps described by Creswell (2013) shown in Figure 9.8.

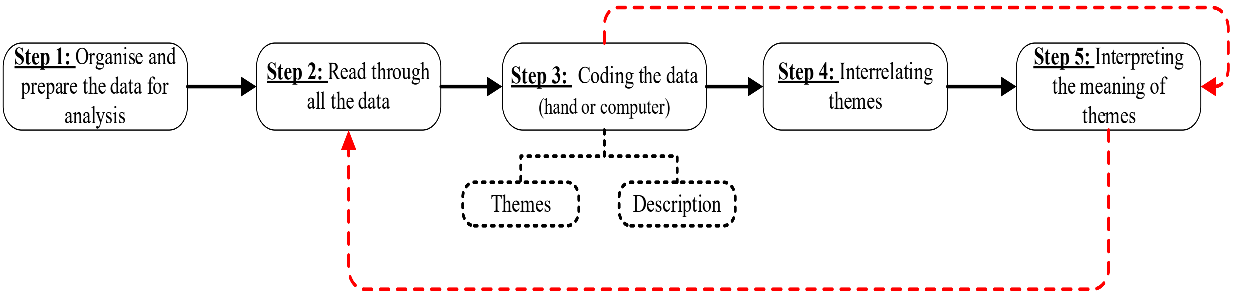

Figure 9.8: Data Analysis in Qualitative Research (Creswell, 2013)

The recorded interviews were transcribed, and the data was categorised around the system functions as identified by the interview guide. This allowed for a structured layout for the data in MS Excel worksheets facilitating the data analysis process. The transcription process also worked as the first round of reading through the data before fully concentrating on the coding process. The codification process was done utilising the R-Qualitative Data Analysis (RQDA)[58] package in R which is an open source Computer-assisted qualitative data analysis software (CADQAS). The coding process was formulated through the interpretation of the researcher by identifying patterns and categorising them accordingly. In this case, base codes emanated from the activities and leverage points identified in literature and the initial evaluation of MAMA and MomConnect cases. The input data for RQDA was just from the interviews. This is because the narratives and the review of the DHIS2 platform had been undertaken from other data sources such as observations, journals, publications, websites, news

[58] http://rqda.r-forge.r-project.org/

and formal reports. The aims of the interview data analysis were to verify concepts and further explore the themes, patterns and categorisation of data.

In this study there were three coding cycles. The first round of coding was identifying the leverage points that had been previously identified from other data analysis. The second cycle was to be more aware of new leverage points that were mentioned by the interviewees. The final cycle was to relook and see if any other themes and deeper insights had been overlooked. This process resulted in various additional concepts and insights which were added to the framework in order to make it as comprehensive and generalisable.

9.2.1 Key Insights from Interviews

The interviews added additional leverage points which the interviewees were either part of or highlighted. The positive aspect was that from the interviews the previously identified leverage points were confirmed so this section highlights additional and important insights that were from the interviews. This section will highlight some of the key perspectives from interview candidates (IC) that came out during the interviews.

9.2.1.1 Training Trainers

An important aspect which came out from the interviews which had not been considered by the author is the aspect of training. Though all the interviewees had been a participant in one or more trainings, what was perplexing was that of the 20 interviewees less than 50% were involved in training others. Various reasons included what IC9 noted that he '*had thought of that but I have not yet had the chance to train others, but given the chance I would like to*'. Hence, the knowledge flows seem to be broken at the point when the implementers and enthusiasts get back into their workspaces and parent organisations. Training and having training protocols is a key leverage point that assists in strengthening an ecosystem through capacity building.

9.2.1.2 Dynamic and Responsive Ecosystem

DHIS2 is in a very dynamic ecosystem as IC14 noted that '*DHIS 2 is dynamic it continues to change based on the user needs*'. These user needs are very wide for a platform like DHIS2. Users range from patients and community health workers at the primary level to the management at the Ministry of health. In that respect the leverage points that are important at every structural stage are different and always evolving. Besides the platform evolving, the ecosystem built around the platform has enabled for '*direct interactions with people from various countries'*- IC8, which would not have been possible previously. These global interactions have had both positive and negative impact. The global network enables sharing of information nevertheless, itis only recently that a platform was provided by HISP Oslo for DHIS2 implementers to utilise. Hence the responsiveness of the ecosystem can be attributed to HISP Oslo having the role of an innovation intermediary. Nevertheless, with such a wide network a lot of data and information tends to fall through the cracks.

A very important aspect has been the evolution of the Oslo DHIS 2 conference from an expert academy to annual conference showcasing in-country implementations and sharing successes and challenges. This might have come up from the migration of the fundamental courses in DHIS2 now being readily available online and more emphasis being placed on monitoring and evaluation (M&E). '*Evaluating trainings and what happens afterwards is important as sometimes we just setup and never return to instances*'-IC20. M&E has been deemed important to see what the ecosystem requires and needs. A summary of the interviewees' perspectives that were additional viewpoints are tabulated and summarised in the next section.

9.2.1.3 Learning in the Ecosystem

One aspect that had not been very clear in literature was the learning process and how it is undertaken. In the DHIS2 ecosystem there is an instance that was noted during the interview process. One of the success stories has been HISP Tanzania where '*The fact that the HISP node in Tanzania is within a learning structure is a very big strength and also issue to do with MOU with the Ministry also affect how far you can go*' - IC2 and '*HISP Tanzania has assisted us with a lot of our implementations*'- IC12. It has been highlighted how in the HISP Tanzania[59] scenario, being in a university and a learning environment, the ecosystem can easily spot students with certain skills who can be easily integrated into the development of the DHIS2 platform. HISP Tanzania has developed so many solutions that have been embedded in the core of DHIS2 as well as by other countries.

9.2.1.4 Knowledge Sharing

Sharing knowledge is an additional aspect that was highlighted, where a community of trainers was important to have. IC6 noted that '*we should have other platforms where people who know should be able to share the knowledge with others who are just joining like in my case I have the knowledge but I have not shared with anyone and if I am to leave now I will go with all the knowledge I know*'. This is where intermediation is important to provide platforms for knowledge sharing, but currently the participation in the ecosystem or touching base with the community of individuals trained in DHIS2 is determined by the individual.

Knowledge sharing feeds into visibility in the ecosystem with the digital landscaping and resource mapping of activities. This assists in standardisation and assisting the technology to have a protocol of sorts. There was note that '*Protocols are not only in knowledge assimilation but also in the technical aspects of the system like when upgrades occur-what version implementing partners should use for synchronisation with the MoH'*- IC8. The fact that a knowledge repository exists is one of the key leverage points that this case study has managed to bring out.

9.2.1.5 Interoperability

One interesting note that came up, which the researcher had not considered, was considering protocols that integrate across all the technologies utilised in interventions. The author had initially thought that basing all the Healthcare Information Systems in a country on a DHIS2 base would assist in ensuring the sustainability of a technological ecosystem. However, IC17 helped give a different perspective by suggesting instead of removing other healthcare platforms that have been implemented by other programs, to rather '*aim to have interoperability and building bridges between the software instead of a monopolistic landscape*'. This interview candidate had a unique perspective as having worked on other implementations and interventions using software such as OpenMRS which in a way compete with DHIS2. Integration is one aspect that countries like Zimbabwe and Malawi are also working towards.

9.2.2 Additional Framework Concepts from Interviews

The additional insights and concepts by the interviewees were identified in Table 9.4.

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[59] https://hisptanzania.org/#/home

Table 9.4: Additional Leverage Points and Intermediary Activities

Leverage point	Ecosystem Activity	Example Ecosystem Activity and Innovation intermediary Role
User inclusion in development process	• Develop applications on the ground	• Regular communication with users during development process • Facilitator -creation of a community platform
Development of Safe spaces	• Creation of safe spaces for women developers-set rules	• Configuration - Moderate platforms to ensure no derogatory language is used
	• Have formal communication channels where developers and implementers interact and it is traceable	• The implementers use email, WhatsApp, calls to communicate and a lot of developmental knowledge is lost in the process • Broker Communication channels
Training	• Enable trained implementers to become trainers	• Make a mandate that certification is maintained through training of other individuals to expand the ecosystem • Facilitator – support training
	• Refresher courses are necessary for previously trained users	• Broker - Provide constant refreshers on taught courses
Learning	• Standardisation of learning curriculum	• Ministry of Education and Health to collaborate of how to teach technologies that are already being utilised • Configuration
	• Use other HISPs for implementations and training	• HISP Tanzania has a lot of expertise when it comes to being able to implement and customise DHIS2. -this was attributed to the HISP node being based at the University • Broker – connections with key HISP organisations
Research collaboration	• Creation of courses and degree programs around DHIS2	• Chancellor University Malawi offers degree programs and Nursing programs around DHIS2 • Configuration – implementation of learning courses
Project Knowledge repository	• Sharing the in-country applications with other countries for quick solution development	• Configuration - Share code and practical examples with other implementer
Infrastructure	• Ministry to check the infrastructural constraints to ecosystem participation	• Facilitator - Supply of hardware
Feedback	• Open process for logging in complaints	• Closed process for sharing queries • Configuration- have communication channels
Monitoring and Evaluation	• Have evaluation models in place to track the effects of the platform	• Used Kirkpatrick's model for evaluating trainings • Facilitator – evaluate impact of trainings
	• Have a generic screening of background of clients	• Studies looking at the profile and outline of the training conditions • Configuration – ensure right candidates are trained and will train others
Implementer database	• Map all projects and what actors are working on • Digital landscaping and Resource mapping	• ITech (Malawi) tried to make a repository -but I don't know if there are people who are using it • Configuration – have a base repository
Technology formulation	• Protocols are not only in knowledge assimilation but also in the technical aspects of the system like when upgrades occur-what version implementing partners should use for synchronisation with the Ministry of Health etc	• The upgrades are systematically put out from DHIS2 but were not updated in the on-ground implementations • Configuration - communicate more openly
Communication channels	• Formalise communication channels	• Broker - Communication is usually through informal channels e.g emails, WhatsApp

A total of 4 new leverage points and 18 additional ecosystem activities were added to the framework. These leverage points were *user inclusion in the development process*, *development of safe spaces*, *Monitoring and Evaluation* and formal *communication channels* for the developers and implementer.

The additional leverage points were from a holistic perspective where the interview candidate had a mix of experiences with the DHIS2 platform and were across both genders.

9.3 Further Expert Feedback reflecting on identified Leverage points

To finalise the framework, the 39 leverage points identified from the ESA narratives, empirical data and case studies were listed and categorised. To do so this study drew guidance from two prominent studies. The first study by Thomas (2013) identified organisational, technological, institutional and contextual activities that drive ecosystem emergence and another study by Thomas et al. (2014) which identified architectural leverage for platform ecosystems. In this study the categorisation of the leverage points was initially *structural leverage, technological leverage, social leverage* and *knowledge leverage*. These categorisations aligned more with the platform and technological nature of the study with less emphasis on one particular organisation shown in Table 9.5.

Table 9.5: Initial Leverage Point Categorisations

Category	Leverage Point Description
Technological Leverage These factors align with the platform's technical aspects and what are the key aspects that make the platform easy to utilise and hence increases its network effects.	Technology formulation- Platform operating system
	Technology usage-Use of technology
	Platform development (e.g. updates)
	Application development (i.e. complementary applications)
	Archetypal design (centralised vs de-centralised)
	User inclusion in development process
	Technology development philosophy (e.g. top down or bottom up)
	Technology focus (who the platform is developed for)
	Data analytics
	Platform network effects
	Platform signups
	Platform usability- accessibility to end users
	Customisation and curation of content
Structural Leverage These factors align with the interaction and actor networks where considering the role of having a key point of contact like the Ministry of Health.	Core facilitator selection
	Research collaborations
	Standardisation across the actors
	Feedback channels
	Formal implementer communication channels (e.g. DHIS2 community)
	Strategic goal alignment
	Running and funding costs
	Vast core platform creators
	Business Model Experimentation
	Open Ecosystem
	Sub-Ecosystems formulation
	Build local ecosystem
	Resource and skills development plan
Social Leverage These factors align with the social aspects in the network	User empowerment
	User inclusion
	Development of safe spaces (i.e. have rules for interacting)
	Build a database of experts

Category	Leverage Point Description
which can either hinder or make the network grow.	Policing (monitoring) the platform
	Advertising ecosystem initiative
Knowledge Leverage These factors align with the how knowledge is created and stored in the ecosystem. This includes looking at ways how knowledge is created, shared and stored amongst actors.	Project knowledge repository
	Learning e.g. blended, interactive -Learning programs (e.g. courses with universities and colleges)
	Learning from the past
	Training-Capacity building (e.g. academies, online trainings)
	Monitoring & Evaluation
	Technology transfer (between organisations)
	Communities of Practice- Knowledge Sharing

9.3.1 Round 2 Expert Interviews

To check if the identified leverage points for the healthcare innovation ecosystems were relevant, missing aspects or irrelevant, two experts were approached. The profiles of the experts are: 5

- **Overall Expert 1 (E1)**: is a public health practitioner who has been involved in digital health platforms and interventions for over 10 years. He is a holder of a Master of Public Health (MPH) degree with specialisation in Medical Informatics and recently completed a Doctor of Technology (DTech) degree in Informatics. He has experience in public health with the National Department of Health, Non-Governmental Organisations (and related development organisations) such as HISP-SA, HealthEnabled and I-TECH SA. The expert has interdisciplinary experience and knowledge in the design, development, adoption, implementation and application of ICT-based innovations in healthcare services delivery, management and planning. Apart from his initial work as a clinician, he has worked in various roles in programs such as health standards compliance, HIS strengthening, digital health implementation in maternal, child and women's health and human resources for health.
- **Overall Expert 2 (E2)**: is a software development manager with a Non-profit organisation, Jembi, that works in developing countries in Africa and focuses on the development of eHealth and HIS. Jembi leads the way on building local capacity within Africa through innovation and commitment towards strengthening of eHealth. Its head office is in Cape Town, South Africa. The expert has been involved in ecosystems that are also in the private sector with Fintech companies and data networking companies also involved in providing infrastructure for such healthcare interventions. E2 has over 14 years' experience in the field.
- **Overall Expert 3 (E3)**: is a technical manager and software enthusiast with over 18 years' experience. The expert has worked with various private organisations in the financial and retail industry. Additional experience has also been in Non-profit organisations including Afrosoft Holdings and Jembi that have worked on interventions and applications in the Healthcare sector. The experience has been in various contexts and countries including Botswana, South Africa and Zimbabwe.

9.3.2 Feedback from Experts on Identified Leverage Points

E1 agreed that the identified leverage points were relevant especially when it comes to healthcare innovation ecosystems. Interestingly, it was pointed out that the identified leverage points left out the political aspects. It was better explained as when interventions are being undertaken, a change in parliament and government affects the continuity of projects as different Ministers of Health might push for different agendas. This results in some commendable project being put aside due to political interests. Hence this is a leverage point that was added in the framework.

Result from E1 feedback: An additional leverage point category called *political leverage* was identified. On a closer look, some identified leverage points like funding and running costs and monitoring the platform had elements that are linked to the political environment. The key leverage point of funding relates to the continuity and viability of the ecosystem.

E2 also confirmed the relevance of such a framework and aligned with the leverage points. He noted that building a community is important. Of note is that open source is difficult to administer across various applications as even if the technology is open source organisations do not necessarily share the applications they develop. Hence an intermediary has an important role to play when it comes to ensuring that the ecosystem actors do interact. E2 highlighted a '*lack of a sustainability plan*' when it comes to interventions and ecosystems. This merges with the point that was outlined by E1 where sustainability is affected by a change in plans. Examples of such initiatives that were good but put on hold are Digital Square[60] a digital health marketplace which was undertaken in collaboration with PATH.

Result from E2 feedback: Conjuring and *designing a sustainability plan* was added under the Knowledge leverage category as an additional leverage point. This holds the intermediary accountable for making sure that even if other actors exit the ecosystem there is always a base solution to at least ensure that the ecosystem continues. Emphasis on longevity was reiterated by the expert.

E3 also said such promptings that were raised by the framework are important. There was consensus that these ecosystems do need some form of intermediary in order to run effectively. The expert did highlight that there is need for understanding that the assumption that utilising open source technology does not necessarily mean that the ecosystem or organisation is part of the ecosystem. E3 stressed the importance of building an open source community. Nevertheless, this expert did not identify any topics which had not been identified in the framework.

9.3.3 Unsuccessful Survey Results

At the beginning of the review process of the relevance of the leverage points, the author posted a survey on the DHIS2 community hoping to get responses. The community has over 350 members. Unfortunately, only three people responded to the survey hence the results were deemed inconclusive.

9.3.4 Final Set of Identified Leverage Points

The final set of identified leverage points were still 39 but with a 5th category called *political leverage*. Other leverage points that aligned more with political leverage were moved to that category – these were funding costs and monitoring the platform.

These additional leverage point category was added, and the funding mechanisms of the ecosystem was moved to the political leverage when it aligned with healthcare ecosystems outlined in Table 9.6.

[60] https://digitalsquare.org/about

Table 9.6: Final Leverage Point Categorisations

Category	Leverage Point description
Technological Leverage These factors align with the platform's technical aspects and what are the key aspects that make the platform easy to utilise and hence increases its network effects.	Technology formulation- Platform operating system
	Technology usage-Use of technology
	Platform development (e.g. updates)
	Application development (i.e. complementary applications)
	Archetypal design (centralised vs de-centralised)
	User inclusion in development process
	Technology development philosophy (e.g. top down or bottom up)
	Technology focus (who the platform is developed for)
	Data analytics
	Platform network effects
	Platform signups
	Platform usability- accessibility to end users
	Customisation and curation of content
Structural Leverage These factors align with the interaction and actor networks where considering the role of having a key point of contact like the Ministry of Health.	Core facilitator selection
	Research collaborations
	Standardisation across the actors
	Feedback channels
	Formal implementer communication channels (e.g. DHIS2 community)
	Strategic goal alignment
	Vast core platform creators
	Business Model Experimentation
	Open Ecosystem
	Sub-Ecosystems formulation
	Build local ecosystem
	Resource and skills development plan
Social Leverage These factors align with the social aspects in the network which can either hinder or grow the network.	User empowerment
	User inclusion
	Development of safe spaces (i.e. have rules for interacting)
	Build a database of experts
	Policing (monitoring) the platform
	Advertising ecosystem initiative
Knowledge Leverage These factors align with the how knowledge is created, shared and stored in the ecosystem.	Project knowledge repository
	Learning e.g. blended, interactive and programs (e.g. courses with universities and colleges)
	Learning from the past
	Training-Capacity building (e.g. academies, online trainings
	Monitoring & Evaluation
	Technology transfer (between organisations)
	Communities of Practice- Knowledge Sharing
	Designing a sustainability plan
Political Leverage These factors align with the political environment.	Running and funding costs
	Monitoring the platform

These leverage points were categorised, which led to modification of subsystem 3 in the framework shown in Figure 9.9.

ECOSYSTEM SUSTAINABILITY

ACTIVITY FLOWS

Ecosystem Functions:
Entepreneurial Experimentation; Knowledge development; Knowledge diffusion; Guidance of Search; Market formation; Resource mobilisation; Creation of legitimacy

EVOLUTION AND EMERGENCE

Function	**Identified Leverage Points**
F1- Entrepreneurial Experimentation	Running costs, Accessibility to End Users, Technology usages, Policing (monitoring) the platform, Business Model Experimentation, Advertising ecosystem initiative, Feedback mechanisms
F2 - Knowledge Development	Learning from the past, Research Institution collaborations, Content Curation, Data analytics, Open Ecosystem, Resource and skills development, Platform signups
F3 - Knowledge Diffusion	Project knowledge repository, Blended Learning
F4 - Guidance of search	Core facilitator selection, Platform network effects, Customisation of Content
F5 - Market Formation	Platform usability, Technology formulation
F6 - Resource Mobilisation	Build a database of experts - Communities of Practice, Technology focus
F7 - Creation of Legitimacy	Vast core platform creators, Strategic goal alignment, Sub-Ecosystems formulation

Changes to

ECOSYSTEM SUSTAINABILITY

ACTIVITY FLOWS

Ecosystem Functions:
Entepreneurial Experimentation; Knowledge development; Knowledge diffusion; Guidance of Search; Market formation; Resource mobilisation; Creation of legitimacy

EVOLUTION AND EMERGENCE

Leverage Category	**Identified Leverage Points**
Technological Leverage	Technology formulation, Technology usage, Platform development (e.g. updates) Application development, Archetypal design (centralised vs de-centralised), User inclusion in development process, Technology development philosophy, Technology focus, Data analytics, Platform network effects, Platform signups, Platform usability,Customisation and curation of content
Structural Leverage	Core facilitator selection, Research collaborations, Standardisation across the actors, Feedback channels, Formal implementer communication channels, Strategic goal alignment, Vast core platform creators, Business Model Experimentation, Open Ecosystem, Sub-Ecosystems formulation, Build local ecosystem, Resource and skills development plan
Social Leverage	User empowerment, User inclusion, Development of safe spaces Build a database of experts, Policing (monitoring) the platform, Advertising ecosystem initiative
Knowledge Leverage	Project knowledge repository, Learning e.g. blended, interactive and programs, Learning from the past, Training-Capacity building, Monitoring & Evaluation, Technology transfer (between organisations) Communities of Practice, Designing a sustainability plan
Political Leverage	Running and funding costs, Monitoring the platform

Figure 9.9: Subsystem 3 Modifications

9.4 Chapter Conclusion

This chapter outlined the application of the modified Ecosystem Emergence and Evolution framework was applied to a practical case. This was the final stage of the progressive evaluation approach that was adopted in this study. Hence, the third and final case study served two purposes; firstly, to test the suitability of the conceptual framework and the process flow as a tool to assist an intermediary organisation to manage the ecosystem. Secondly, as a source of identifying additional leverage points in the framework.

The case analysis consisted of ESA ecosystem lifecycle narratives, meta-synthesis of empirical studies, 20 semi-structured interviews –all addressing the DHIS2 innovation ecosystem and 3 SME who have worked with various platforms. The uniqueness of this study is that due to less theoretical work aligned with leverage points in innovation ecosystems it aimed to also use the data that comes out from the cases to inform the exact categorisation of the leverage points. This was in a grounded theory way,

The next chapter presents the finalised elements of the management tool for ecosystem engagement: the final conceptual framework and the process map outlining the procedure for using these elements to proactively manage an innovation ecosystem.

Chapter 10: A Tool for Ecosystem Emergence and Evolution Management

"If you look at history, innovation doesn't come just from giving people incentives; it comes from creating environments where their ideas can connect." — Steven Johnson

This chapter presents the final framework and introduces how the framework can be applied as a tool. It starts with the motivation for the tool's development and its intended purpose. Thereafter, the final conceptual framework and its progression into a management tool is briefly described. A procedure for applying the management tool is outlined to guide user application.

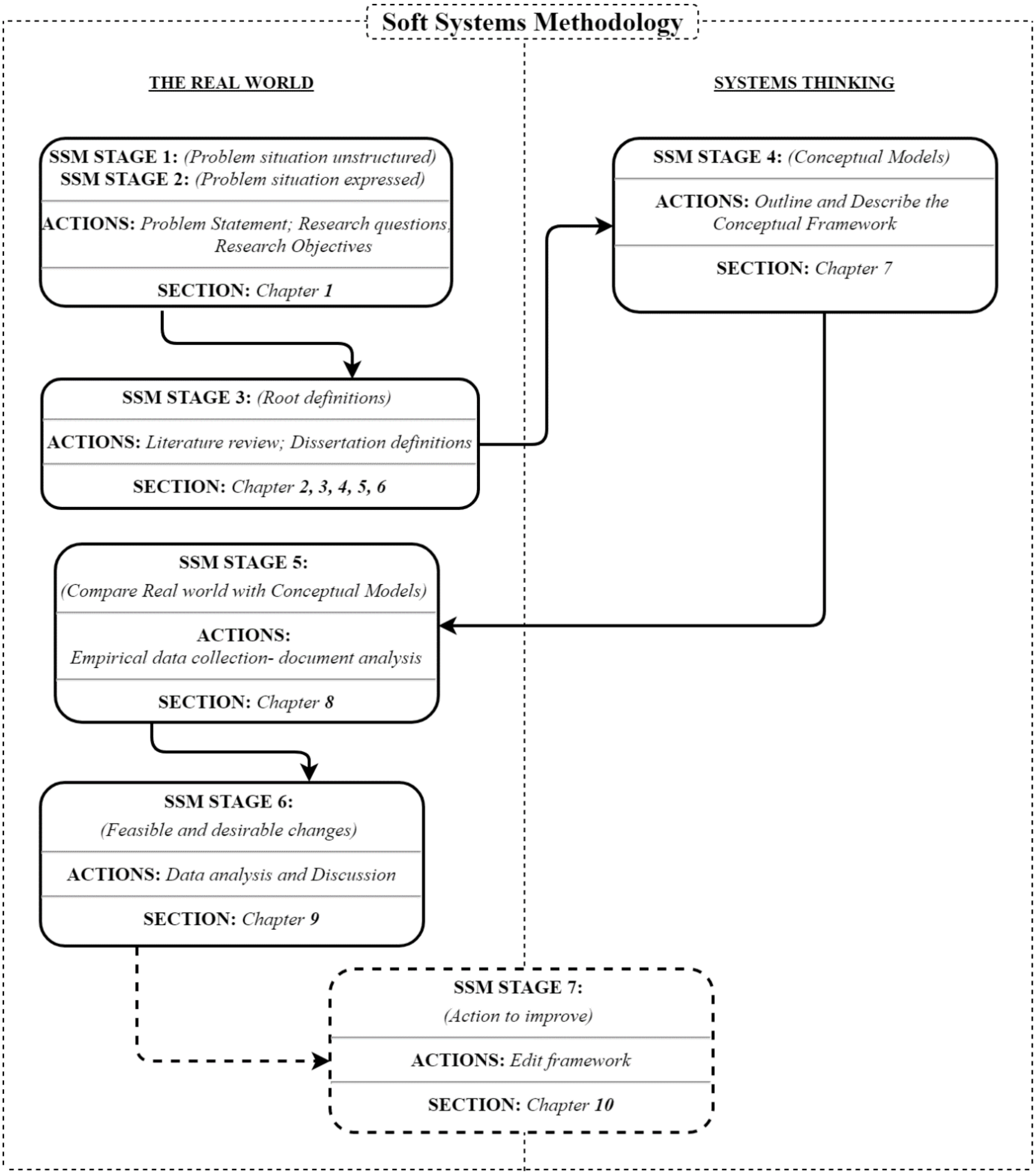

Figure 10.1: The Placement of Chapter 10 within the Context of the Soft Systems Methodology.

10.1 Motivation and Purpose of the Tool

The tool in this dissertation is designed to be a part of the possible solutions to the key building blocks of a health system. Other pillars can also be addressed in various ways depending on what the ecosystem needs are. This stage involves looking at the core capabilities that are required and the effort towards collaborative problem solving. Making sure that the ecosystem's overall goals align with these activities is of paramount importance. A well-functioning Health Information System (HIS) is one that ensures the production, analysis, dissemination and use of reliable and timely information on health determinants and health system performance (Matavire, 2016).

As such, the HIS, in developing country health systems, have been migrating from being paper based to increasingly becoming digitised (Manda, 2015; Matavire, 2016). In many developing countries this migration process has occurred in a rather fragmented way where information needed for decision-making may be unreliable, ineffective, and insufficient (Dehnavieh, Haghdoost, Khosravi, et al., 2019). This varies according to stakeholder interests and what they intend to be outputs of the ecosystem. Figure 10.2 shows the WHO pillars for an effective health system (World Health Organization, 2007).

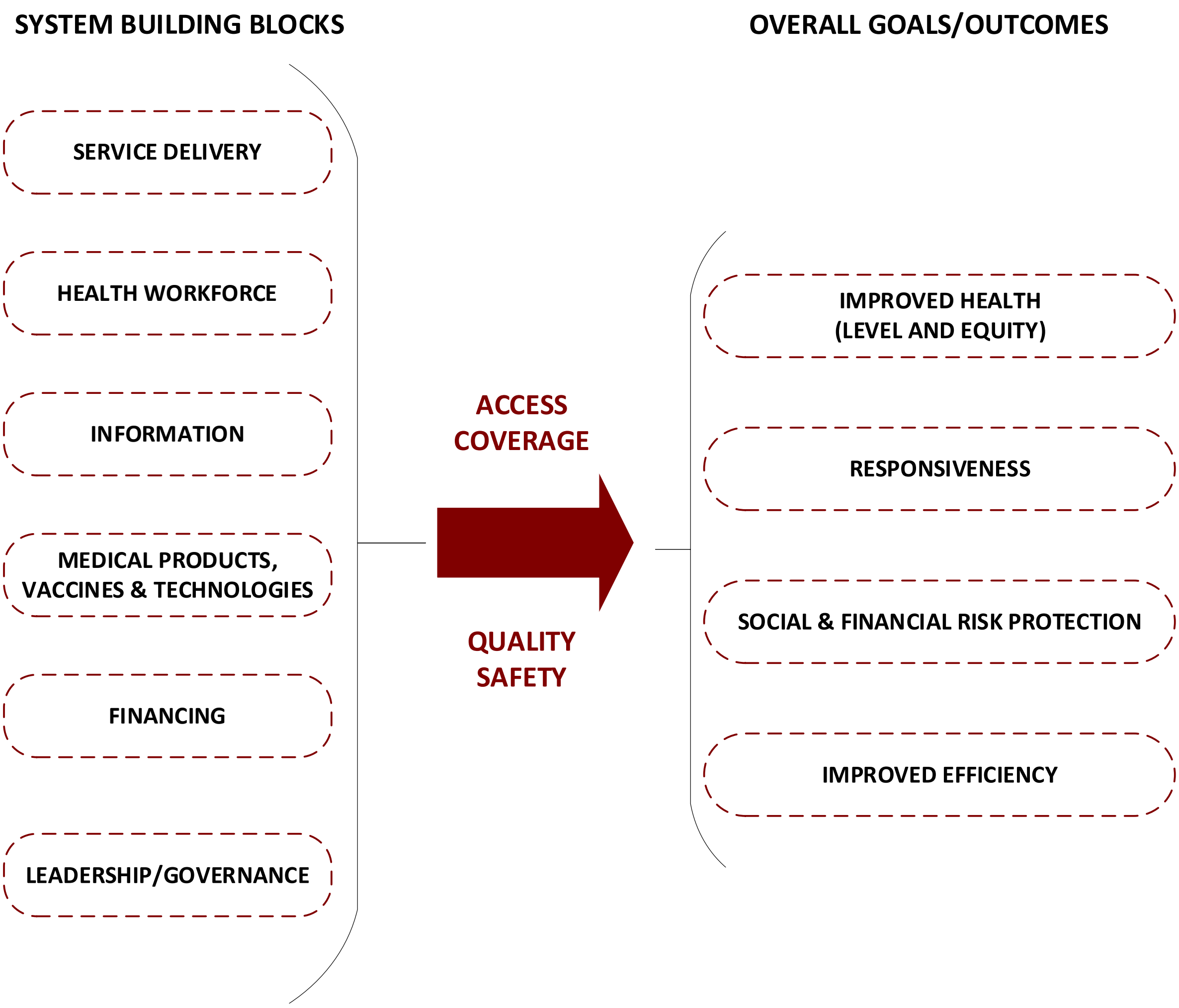

Figure 10.2: Health System Building Blocks. Source: (World Health Organization, 2007)

In the formulation of the ecosystem strategy then a consideration of the health system building blocks in informing the decision is important. Table 10.1 gives an example of such alignment whilst integrating with the innovation ecosystem perspective.

Table 10.1: Integration of Innovation Ecosystem Perspective with Health System Building Blocks

Building Block	Example of Innovation Ecosystem application
Service delivery	• Consideration of delivery pathways across the ecosystem • Process improvement through new systematic approaches • Optimisation of delivery of care within facilities through streamlining operations. • Waste reduction projects • Development of improved M&E indicators and frameworks through all ecosystem actors
Health workforce	• Workforce satisfaction improvement projects. • Staff placement and distribution • Training of competent, responsive and productive staff • Allowing staff to take ownership of facility projects • Staff empowerment through brainstorming sessions and through transparent ecosystem function • Provide the opportunity to influence policies and investment plans.
Health information	• Encourage ecosystem actor buy-in using standardised platforms for projects information. • To promote sharing of resources to avoid duplication and fragmentation of services. • Development of facility and population based information and surveillance systems • Advocate global standards and identify or develop tools to aid in optimal use of available data.
Medicine and technology	• Work with current systems amongst actors to see how visibility of the ecosystem can be achieved • Ecosystem investment into healthcare technologies that are context specific to identify new developments in medicine and technology • Assess and influence the standards, policies and procurement procedures
Healthcare financing	• Improved tracking of health expenditure through data collection tools. • Investigate how ecosystem actors can compete and collaborate to improve financing mechanisms
Leadership and governance	• Promote ownership and to empower members to act proactively • Utilise M&E indicators in strategising ecosystem evolution, resources needed and selecting the right intermediary roles

The next section describes the design criterion that were considered for the tool.

10.2 Tool Design

10.2.1 Tool design recommendations

The tool design recommendations are based on findings in literature as well as feedback from the framework verification and evaluation process. The key highlights are that the tool should:

- improve coherence amongst the ecosystem actors (Autio & Thomas, 2019; Thomas & Autio, 2020)
- assist in the creation of agile (healthcare) innovation ecosystems (van der Merwe *et al.*, 2020; Phillips & Ritala, 2019)
- learn from other streams of research to inform tools or frameworks for innovation ecosystems (section 3.1.4)
- develop ways to learn from the past and minimise the resources that are used during conceptualisation of the ecosystem (Kamrani & Azimi, 2010)
- have outcomes that align with the WHO health system building blocks and eventually the strategic goals of the context that the innovation ecosystem operates in (World Health Organization, 2007).

To ensure success of the tool, then, key activities should be to "*identify and evaluate alternatives, manage uncertainty and risk in our systems, design quality into system and handle program management issues that arise*" (Kamrani & Azimi, 2010: 7).

10.2.2 Final Ecosystem Evolution and Emergence Framework

Before outlining the tool, the final framework has to be presented. The major changes in the framework is the introduction of an outline of the 39 leverage points and the categories that these leverage points belong to. The final framework is shown in Figure 10.3.

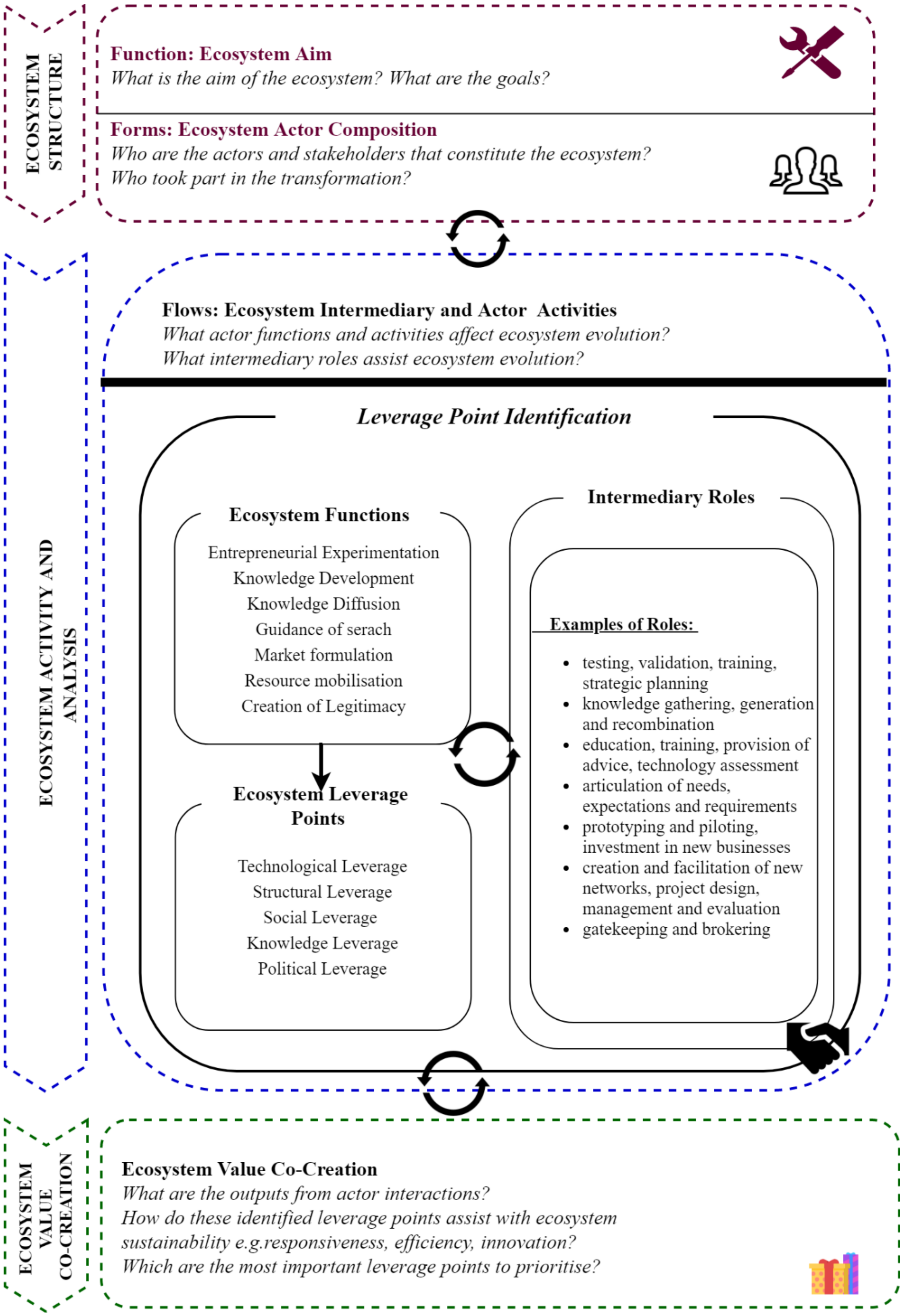

Figure 10.3: Final Ecosystem Evolution and Emergence Framework

10.2.3 The Proposed Ecosystem Evolution and Emergence Management Tool

The tool provides a foundation for an ecosystem actor with the role of an innovation intermediary for identifying key activities that are important to focus on in the ecosystem. This can assist the intermediary think proactively develop a preventative plan prior to investing in the platform's development.

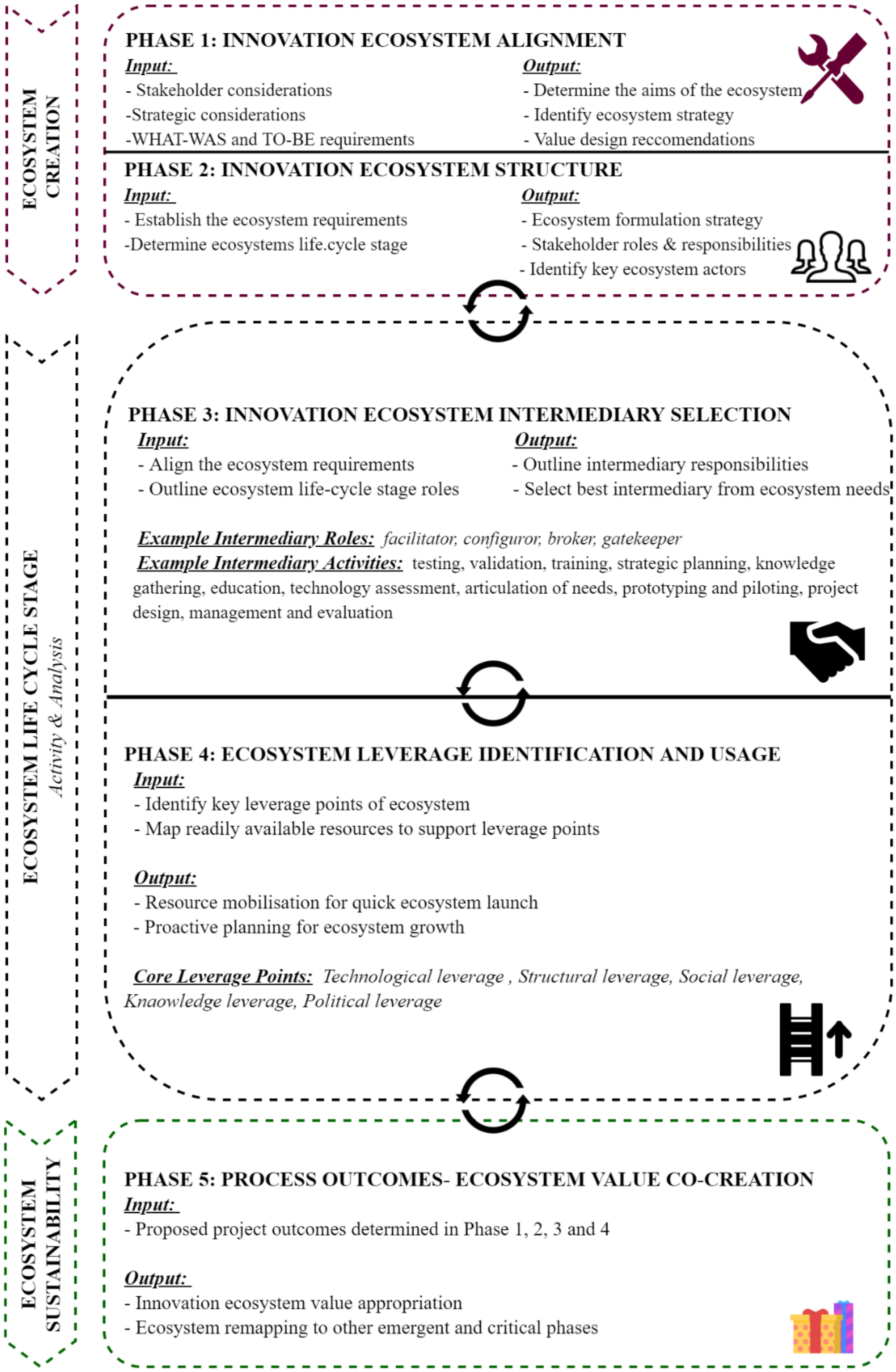

Figure 10.4: Ecosystem Evolution and Emergence Management Tool Outline

Figure 10.4 presents a pictorial depiction of the relationship between the tool's phases. The respective inputs and outputs of each phase are listed. The functioning of the tool is dictated by the outcomes of Phase 1 and Phase 2. The detailed approach to the usage of leverage points in the ecosystem management process implementation is undertaken in Phase 4.

10.2.3.1 Phase 1- Innovation Ecosystem Alignment

Phase 1 looks at the alignment and is informed by the following questions:

1. What is the purpose of the ecosystem?
2. Who are the actors?
3. What competencies are currently in the ecosystem and required to meet the ecosystem purpose?
4. What are the boundaries?
5. What lifecycle stage is the ecosystem in?

10.2.3.2 Phase 2 - Innovation Ecosystem Structure

The formation of the innovation ecosystem without boundaries is dangerous. Hence a break down of complex ecosystems to defined ecosystems to distinguish one from another and form boundary conditions is necessary. This aligns with the aspects of reductionism that are still relevant to complex systems described in section 2.1. In natural ecosystems this now goes further to the identification of the various species in the ecosystem such as the primary producer species and understanding of the context in which the ecosystem resides. Context plays a key role in resource accessibility and hence collaboration is necessary for sustainability. Innovation ecosystems are designed and developed as a response to the innovation challenges that are occurring in the healthcare sector by creating an environment for accelerating the development and adoption of products, services, and quality standards to obtain good outcomes. Hence close attention should be paid to the development procedures. This comes back to the recommendations by Adner, mentioned in Chapter 3. In the formulation of the ecosystem strategy then a consideration of the health system building blocks in informing the decision is important. Table 10.1 gives an example of such alignment whilst integrating Phase 1.

It is crucial that ecosystem actors take ownership of a project and that they adopt a holistic understanding of the context within which they function. Phase 1 is informed by the questions asked in section 7.3.1 of this dissertation. Additional questions that have come up from the case studies that address the value creation and co-creation aspects are:

- How are we contributing and documenting knowledge from the firm's internal processes to the ecosystem?
- What are the ways that the ecosystem will nurture, sustain, and protect investments and the intellectual capital?
- Is there a system to capture and exploit different sense-making patterns and discovering needs?

Additional questions that give clarity are given below for stakeholder considerations and network effects.

- <u>Stakeholder considerations:</u>
  - *Goals*: have a good understanding of their needs and objectives which they expect will emerge from being within this partnership?
  - *Relationship*: Do the actors know each other? Have they worked together before?
  - *Experience*: Are there any ecosystem actors that have been involved in a similar project?

  - *End-user considerations*: What will engage end-users? How do they consider their contribution and value?
  - *Technology*: What technology choice is there for i) communication between ecosystem actors ii) communication with end users Does the technology capture, communicate and give access to creating knowledge so the insights collected can be translated and distributed to the stakeholders involved.
- Network and Network effects:
  - *Architecture*: What design (s) will promote highly fluid and adaptive ecosystems? Should clustering for the ecosystem be considered
  - *Ecosystem dynamics:* What ongoing relationships, interactions, past contributions build stocks (knowledge) or flows (insights)?
  - *Interactions*: What protocols and standards enables greater clarity? How is mutual sharing, trust, reciprocating, and a common sense of identity cultivated? What channels are open for such interactions?
  - *Data*: How is data collect? What are the indicators and data points? How are interactions measured?

10.2.3.3 Phase 3 - Innovation Ecosystem Intermediary Selection

After ascertaining the value and structure of the ecosystem from Phase 1 and 2, it is now important to determine the roles that are key in getting the ecosystem to quickly have an impact. These are the roles outlined in Chapter 5 , grouped under the innovation functions mentioned in section 5.3. The reorganisation in this dissertation comes from the identification of the ecosystem's needs and key activities that are required from the intermediary in order to efficiently identify and execute around the identified leverage points.

10.2.3.4 Phase 4 – Ecosystem Leverage Point Identification and Usage

The intermediary now aligns the type of leverage that is required for the dynamics and life-cycle stage that the intended ecosystem is in. This allows for improved resource allocation and streamlined focus areas.

10.2.3.5 Phase 5 - Expected Process Outcomes

The key process outcomes of the framework refer to the identified areas from Phase 1 to Phase 4. This is aimed at evaluating the activities that the ecosystem concentrates on for survival and to move and grow from one stage to the next. To conclude Phase 5, the overview of the main objectives are expanded on around value co-creation, knowledge management and increasing innovation capacity shown in Figure 10.5.

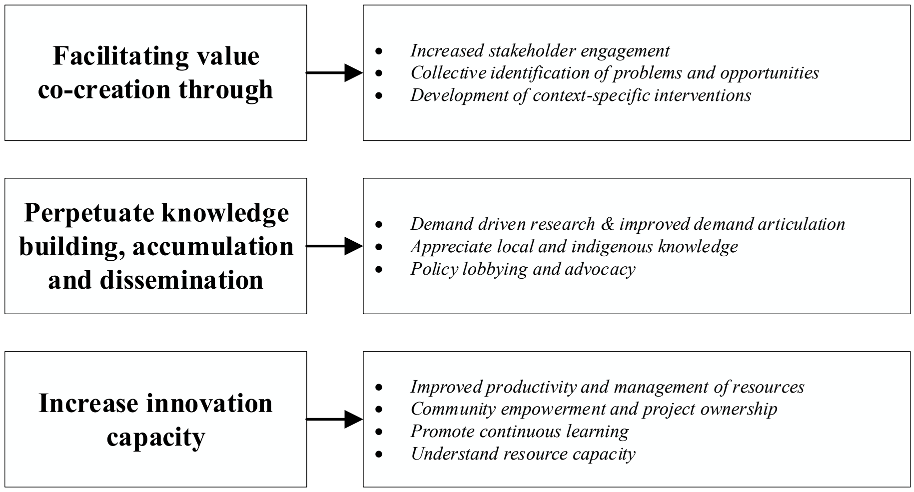

Figure 10.5: Framework Objectives

10.3 Chapter Conclusion

This chapter presented the overall framework and the amendments done to the framework. A tool was developed from the framework to guide the usage of the framework. The systematic approach towards developing, description and relationship between the phases was outlined and provides an expanded view of the final framework. Take note that these phases most likely occur simultaneously at varying degrees. The next chapter concludes the research study presenting a concise summary of the conducted research, the study findings, limitations, and recommendations for future work.

Chapter 11: Conclusions and Recommendations for Future work

"*There's no good idea that cannot be improved on*." — Michael Eisner

This chapter presents the summary and reflections on the study suggesting research directions and limitations of the study.

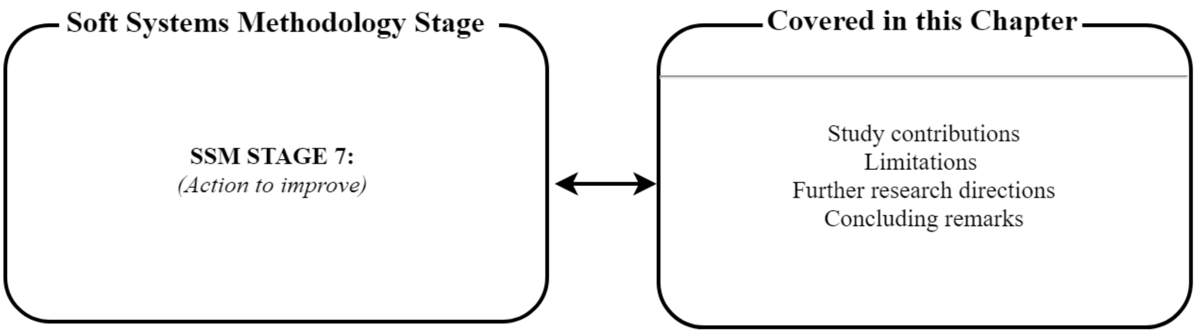

Figure 11.1: The Structure of Chapter 11 within the Context of the Soft Systems Methodology

11.1 Research Summary

This dissertation addressed the integration of intermediation in a framework to guide the development and emergence of innovation ecosystems. To do so, an investigation was undertaken both theoretically and empirically in the context of two HealthCare oriented innovation ecosystems. Shown in Figure 11.2.

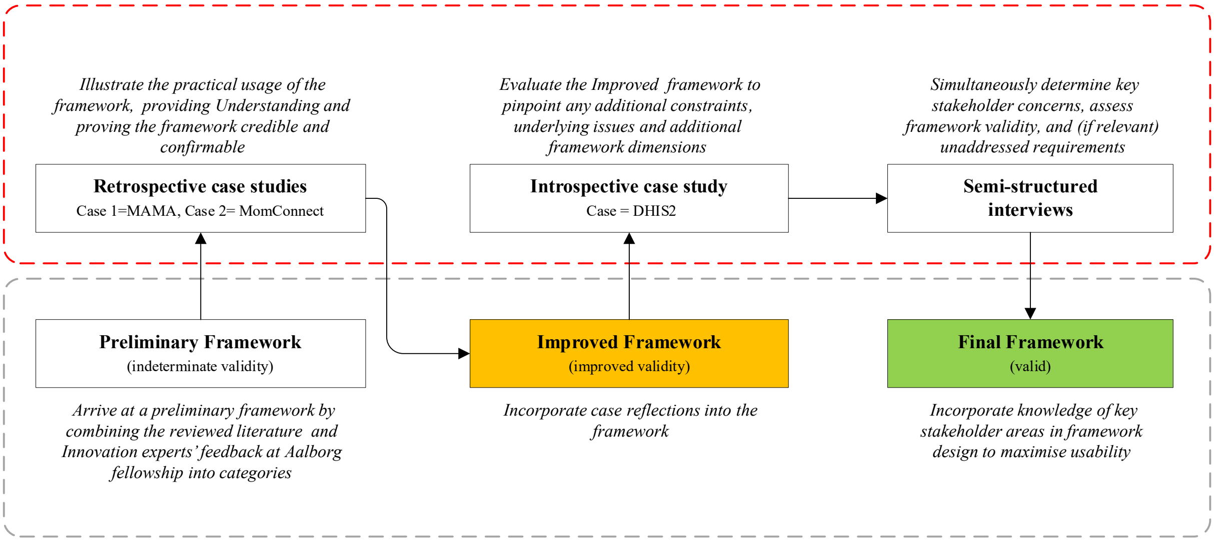

Figure 11.2: Framework Formulation

The framework development process was theoretically guided by Soft Systems Methodology and included:

a) the integration of Innovation Systems theory (systemic functions) as directives on the activities undertaken in the Innovation ecosystems *(Chapter 3)*

b) substantiating the definition of innovation ecosystems and how they can be equated to a complex adaptive system with particular behaviours that contribute to explaining the emergence of the ecosystem (*Chapter 4*)
c) categorisation of the elements that innovation intermediation can be addressed in terms of roles and overarching characteristics of structural arrangements, boundary spanning and competencies. *(Chapter 5*)
d) identifying aspects that align with value, value creation and cocreation *(Chapter 6)*

The framework was presented in Chapter 7 and then empirically evaluated and validated in Chapter 8 and Chapter 9 through an analysis of the identification of the leverage points that guide the emergence of three different innovation ecosystems. The three phases of the ecosystem life cycle used as reference were of Birth, Expansion and Self-Renewal (death or re-birth) as identified by Moore (1993). The selected innovation ecosystems in this study exhibit distinct differences across all the phases due to the differences in formulation and strategic objectives. Though an explanation was done of these differences through the narratives, emphasis was on the core idiosyncratic leverage points and attractors and an argument was put forward on the logics of value co-creation and path dependency which resulted in various similar and a few dissimilar leverage points. Chapter 10 discussed the final framework and introduced a tool specifically considering the important role of the logic of value co-creation on ecosystem emergence and evolution.

11.2 Research Contributions

The primary contribution of this thesis is that it offers a framework that guides the management of an innovation ecosystem named the Ecosystem Evolution Framework. This acts as a starting point that enables the future modelling of innovation ecosystems and identifying plus analysing ecosystem actor interactions. The study overall contributes the current body of knowledge in these three ways described below.

11.2.1 Methods for Investigating Innovation Ecosystems

This study provided new insights into how innovation ecosystems can be investigated. The methodological contribution of the study is related to the steps undertaken to understand innovation ecosystems utilising Soft Systems Methodology integrated with Event Structure Analysis. This enabled the narrative analysis of innovation projects and how they can assist in the emergence of new innovation ecosystems. Previously it has been pointed out that an analysis of the emergence and logics of value co-creation of failure cases and comparison with those of a successful ecosystem is important (Thomas, 2013). That is one of the primary things this thesis aimed to address through the MAMA and MomConnect case studies where the direct inspection of MAMA provided means to identify and analyse the key decisions that differentiated between ecosystem success and failure.

11.2.2 Innovation Ecosystems as Intermediated Complex Adaptive Systems

In this research, a number of key success factors and barriers were identified and used in the verification process of the methodology. One key area that has been recurring is that of merging innovation ecosystems with complexity science (Phillips & Ritala, 2019; Ritala & Gustafsson, 2018; Russell & Smorodinskaya, 2018). Though some studies have used the complexity lens in ecosystems research (Phillips *et al.*, 2017; Roundy *et al.*, 2018), this study has gone a bit further by addressing the actions and strategies that a hub firm (innovation intermediary) can use to construct an ecosystem. The research adds an additional perspective of how the changing innovation intermediary roles are key in guiding actor interactions which affects the emergence and evolution of the ecosystem.

11.2.3 Identification and Categorisation of Leverage Points in Innovation Ecosystems

Integrating Innovation systems functions as a guide to understanding innovation ecosystems is not that common to innovation ecosystems discourse. This was used to inform the process of how to identify and use leverage points in innovation ecosystems which contributes to ecosystems' the body of knowledge. The proposed framework and tool (with 39 leverage points) can be used as a guide and checklist for the formulation of innovative spaces. It also facilitates an understanding of the life cycle of an innovation ecosystem, paying attention to its inputs and outputs. This contribution is significant because it empowers current and future facilitators and stakeholders to design and deploy new sustainable innovation ecosystems that are beneficial all the stakeholders. The consideration of field-configuring events as some of the key elements to the emergence of ecosystems has been an interesting finding.

11.3 Limitations

There are a number of limitations of this study. As a starting point though the cumulative framework resulted in generalised groupings of the leverage points that an innovation intermediary can look at, this framework only considered empirical cases and included interviews with experts in the healthcare sector. Nevertheless, this framework is applicable in various in-country contexts as the information was gathered from professionals that have worked across different contexts.

Another limitation is that the leverage point identification and classification from utilising Soft Systems Methodology and Event Structure Analysis relies mainly on the interpretation and perception of the analyst or researcher. This means that strictly replicable results might not be possible, especially as innovation ecosystems are unpredictable. What can only be predicted are particular behavioural patterns. In larger studies this prediction and any differences in the coding scheme can be circumvented and made more precise through being verified by other researchers on the team to improve reliability. Hence such methodologies are more robust when utilised by a team of researchers than by a single researcher. Nevertheless, this does not negate the importance of the study as it suggests an alternative way to look at and analyse innovation ecosystems.

There are also a number of methodological limitations. Firstly, on the aspect of event database collation and categorisation, there are some events that can possibly be undocumented, or because of language disparities or access issues, undiscoverable to the researchers. This means that the holistic understanding of the way events occurred might be skewed and hence offer a biased perspective of the innovation ecosystem leverage points. Moreover, the reduction of narratives to sequences which are coded can mean that the elements of the narrative structure are systematically removed (Thomas, 2013). An additional concern is how all events had the same extent of influence in the identification of leverage points. Although in this study this does not affect the formulation of the framework, it is important to be considered for future studies. This is an important aspect to consider when using other techniques like optimal matching and frequency analysis.

11.4 Further Research Directions

A number of areas warrant further research both theoretically and empirically.

11.4.1 Research focus

The testing of the framework and further development in other types of ecosystems would be of interest to consider when it comes to understanding the leverage points in complex socio-technical systems. The assumption is that leverage is affected by the main purpose of the ecosystem as well as the value that is created and appropriated by the actors.

11.4.2 Methodology

It would be of interest to see if other types of narrative methods such as Event History Analysis (Negro & Hekkert, 2008; Poole *et al.*, 2000; Suurs, 2009) or Process analysis (Hekkert *et al.*, 2007a) can be utilised for the analysis and cementing of the framework or contradicting the findings in this study. Information is found in the frequency of the events and the variance of the code frequencies within each phase. Examples of such events that can be counted are field configuring events (e.g. meetings, workshops or conferences). Thus, the frequency of particular interactions or events could act as deeper indicators for underlying dynamics in the ecosystem. However, getting enough data points and information to cumulatively build such interpretations could be cumbersome hence it is more suited for longitudinal studies.

Moreover, the order in which events occur is also another additional aspect that can bring clarity to the emergence of an innovation ecosystem, but really pegging accurately the sequential order of events all depends on the angle the empirical data collection process is from. To clarify that, if the narrative is being founded on the perspective of the public organisations, it will definitely have a different order from the perspective of private organisations that are involved in the same initiative in an innovation ecosystem. Having comparative case studies between different types of ecosystems has the potential to validate and extend the findings of this thesis. Re-coding the event data from an actor perspective and identifying the primary actor might be a fruitful approach to understanding more the actor dynamics.

11.4.3 Event representation

The above can also apply to representation of the events. In Soft Systems Methodology, there is the usage of systemigrams[61] which were conceptualised by Boardman and Sauser under the Boardman Soft Systems Methodology. This was conceptualised as a way to view Systems of Systems and providing schematic visualisation of the complexity and elucidation of the key attributes that contribute to the emergence of the system (Boardman & Sauser, 2008). The systemigram is a mixture of prose and pictures with a basis that can be explained from neuropsychology. Such representation gives an added perspective to the case narratives. Future work may consider the use of these mechanisms.

[61] A systemigram was formulated by John Boardman and Brian Sauser It stemmed from having a diagrammatic representation of the situation that is being analysed under SSM. These diagrams were formulated qualitatively and comprised of both syntax and grammar. (Boardman & Sauser, 2008: 100).

11.4.4 Attractor and leverage point identification

With other variations of attractors being strange attractors, social attractors and structural attractors (identified in Chapter 4), a potential research direction would be to reflect on the leverage points and attractors that have been identified in this study. This is done in order to assess under which category they fall; this can eventually assist in modelling the behaviour of ecosystem actors or intermediaries around such attractors. An example of such though patterns is exemplified in the attractor basins that are identified by Lindhult & Hazy (2016).

11.4.5 Attractor and leverage point categorisation

This study was done from a macro perspective. Hence the leverage points identified in this study start from the premise of asking 'What exists?' to begin with. An important aspect is the categorisation of these leverage points according to the level of difficulty when it comes to implementation. This can be undertaken by conducting a survey with experts. Additionally, assessing the types of interactions and activities according to the ecosystem dynamics is important. As noted by Pistorius & Utterback (1995, 1997), assessment of the types of actor interactions and how that affects the leverage points is of importance in the innovation ecosystem dynamics. This can be competition, symbiosis or predator-prey interactions.

11.4.6 Data analytics

An innovation ecosystem is a data-rich network and analysis of actor interactions is one of the key ways of improving sustainability. Once the facilitator has created the innovation space where actors interact, it is of paramount importance to be able to proactively plan for the needs of the ecosystem through analytics. Mohan et al. (2019) showed possibilities of the use of machine learning in measuring digital health program effectiveness when they evaluated two digital health programs in India. They illustrated possible applications of machine learning to improve implementation.

Usage of other techniques for analysis like Natural Language Processing [62], text mining or sentiment analysis in cases is also important to see how further identification of leverage points can be undertaken. This can also mean using other data sources such as Twitter. A study by Daniel (2020) on the applications of Natural Language Processing on MomConnect that can assist in scaling it efficiently are such examples. The study investigated the possibility of automating the manual answering process which currently has a mean response time of 20 hours.

More importantly, with the technological and virtual aspects that have been rampant around ecosystems now, especially with the advent of COVID-19, this creates another area for analysis. Methods of analysis such as Web Content Analysis and Webscraping of core websites and online platforms that house communities (e.g. the DHIS2 community) are an additional way that innovation ecosystems can be improved. The results can assist implementers with timeous analysis of leverage points, identification of key issues, coordinate, get information and get assistance whilst undertaking implementations. The analysis of the platform helps to

[62] https://www.jacarandahealth.org/

get key issues that implementers face. Interestingly, the DHIS2 ecosystem case that was selected in this study now gives courses on how to track events on the platform[63]

Mapping how an instance of the platform was implemented for the delivery of a particular healthcare intervention would be an ideal way of mapping ecosystem evolution or an in-country context instead of an overview. Considering the effect of context on ecosystems it is assumed that other leverage points will either be discovered, or the importance of one leverage point on another will be expected.

11.4.7 Stakeholder engagement dynamics

Though it seems as if actors would be eager to be part of an ecosystem in order to produce some tangible value. It is not necessarily true when it comes to the reality on the ground. Hence, an important research direction would be to understand the costs of stakeholder engagement. These can be tangible or intangible costs.

11.5 Concluding Remarks

To conclude, this dissertation investigated the intermediation and emergence of ecosystems – an under researched area. This study developed an inductive approach to ecosystems, arguing that an ecosystem is a complex system that speaks back; it also theorised 39 leverage points that drive ecosystem emergence. Theoretically and empirically, this research contributes to our understanding of ecosystems, innovation intermediation and complexity in interactions. It also provides practitioner guidance. The hope is that the findings in this study will inspire fellow researchers and ecosystem facilitators to further investigate why and how ecosystems emerge.

Create for me a space that I am free
Create for me a space that I can be
Create for me a space of liberty
-- ***Empress Chichi***
Here's to creating safe innovative spaces!!

[63] https://academy.dhis2.org/courses/course-v1:HISP+D2EVENTS100+Q2_2020/about

Chapter 12: References

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Appendices

Appendix A: Innovation Ecosystems Research Gaps

Table A.1: Summary of research gaps in literature Source: Authors' elaboration

Reviewer	Review Description and Purpose	Identified Research gaps
(Peltoniemi & Vuori, 2004)	– Literature review and conceptual analysis of business ecosystem aligned with CAS aspects of self-organization, emergence, co-evolution and adaptation	**Ecosystem Analysis:** – studying the ecosystem as a Complex Adaptive System
(Yawson, 2009)	– Suggested elements that an innovation policy that is implemented in innovation ecosystems should encompass	**Ecosystem Analysis:** – further research in predictive validity of suggested innovation ecosystem measurement models – develop complementary perspectives from psychology or socisology to udersytand social and behavioural issues amongst ecosystem actors – have multi-disciplinary, transdisciplinary and inter-disciplinary theoretical foundations for analysing complex constructs such as innovation ecosystems
(Thomas and Autio, 2012)	– Ascertained characteristics that define the ecosystem boundaries – Provided a theoretical framework that's assists in ecosystem modelling	**Ecosystem Value Capture:** – investigate concept of fair value capture in both an empirical or theoretical manner; – track sources of value, value co-creation and capture as boundaries of ecosystems – focus on ecosystem level network competitive strategies **Technological, Activity and Value architecture:** – more analytical work and models to do with alliances, firms and platform levels of the ecosystem – further development of the ecosystem construct and ecosystem model
(Durst & Poutanen, 2013)	– Derived success factors that are essential supporting the implementation of innovation ecosystems- e.g. resources, governance, strategy, leadership, partners, technology, clustering	**Ecosystem Analysis:** – investigate measures to better control and allocate actor resources for business operations – analyse ecosystems from a people-perspective how they support or hamper innovation ecosystems – more longitudinal and mixed methods studies – country comparison studies to consider what factors remain constant under different conditions
(Gawer and Cusumano, 2014)	– Bring together industrial platform literature on internal and external platforms and how it relates to managing innovation ecosystems.	**Ecosystem Emergence**: – lack of knowledge on how (industry) platforms emerge addressing the questions of platform emergence and ecosystem creation – more hypothesis development and testing of how internal platforms evolve to external platforms **Innovation**: – understand the impact of platforms on innovation and competition – examine the role interfaces and architecture of platforms highlighting the potential trade-offs between collaborative system innovation compared to discrete products
(Thomas, Autio, & Gann, 2014)	– Offer coherent theoretical grounding for platform ecosystems through systematic review of 183 articles	**Ecosystem Emergence**: – how platforms emerge and ecosystem creation – emergence and evolution of ecosystems **Theory Testing:** – theory testing of how a platform evolves
(Autio and Thomas, 2014)	– Summarised insights related to ecosystem boundaries, structure and coordination – Reviewed theoretical perspectives that can be applied to ecosystem research i.e. value creation, network embeddedness and network management.	**Ecosystem Control mechanisms:** – understand control mechanisms that enable actors to influence ecosystem evolution around shared platforms and critical assets – understand control migration as ecosystems evolve **Ecosystem Value Creation:** – understand how value is created and delivered within the ecosystem – assess to what extent the value is co-produced, based on services, tangible and intangible assets – understand how external networks influence the value creation process **Technological, Activity and Value architecture:** – understand design principles of shared technological resources and platforms and roles around such ecosystems define structure and composition of innovation ecosystem that emerges around core plat
(Tsujimoto, Kajikawa, Tomita, & Matsumoto, 2015)	– Relooked at the definition, streams of research and significance of research of innovation ecosystems through review of 90 studies	**Ecosystem Analysis:** – continual improvement of the concept, definition and methodology – institutional theory, game theory and decision making theory might include useful insight for ecosystem research – use of action research on the building of a new ecosystem may provide insights
(Valkokari, 2015)	– Review how different ecosystem types differ in terms of outcomes, interactions, logic of action and actor roles	**Ecosystem Analysis:** – analyse actor interactions between various types of ecosystems variety of forms of interaction are required; the interaction between various types of ecosystems – investigate more thoroughly the mechanisms and rules governing the interaction within different types of ecosystems – explore how ecosystem actors perceive their concurrent roles in different ecosystems.
(Schreieck, Wiesche, & Krcmar, 2016)	– Show that platform ecosystems have been analysed either as technology or market-oriented through a review of 97 articles.	**Ecosystem Analysis:** – suggestion to integrate market and technology oriented perspectives when analysing platform ecosystems – integration of complementors and end-users when analysing ecosystems – analysis of ecosystems participants individually – study of data as a boundary resource in more detail

Reviewer	Review Description and Purpose	Identified Research gaps
(Oh, Phillips, Park, & Lee, 2016)	– Offered a critique of innovation ecosystems research and suggested research gaps and directions	**Ecosystem Analysis:** – finding metrics innovation ecosystem performance – look at aspects of ecology but not the whole construct of ecosystem and instead focus on particular aspects in order to meet the needs of artificial ecosystems , not just metaphors – look at non-technological aspects such as strategy, culture, organisation and institution to build competency of ecosystems **Ecosystem Definition:** – clarifying how innovation ecosystems differ from innovation system
(Aarikka-Stenroos, Peltola, Rikkiev, & Saari, 2016)	– Systematic review of 157 articles to map out the emergence and development of business/innovation ecosystem research and propose theory and future research	**Technology evolution:** – how technologies' roles change over time in an ecosystem and the roles of agents in this process **Ecosystem Management**: – understand business ecosystem operational mechanisms – types of roles as part of the ecosystem construct – the role of social proximity **Ecosystem Value creation and capture**: – understand the effect of different cultural contexts; – measuring the benefit for the company to be in the ecosystem; – using complexity theory to assess value creation, – effect of network structure on value creation; value proposition design; complementary products' role in the success of ecosystem – Ecosystem building mechanisms for healthcare of poor people and ecosystem mapping of firms addressing poverty **Ecosystem Analysis:** – finding metrics innovation ecosystem performance
(Iyawa, Herselman, & Botha, 2016)	– Identified components of digital health to define digital health innovation ecosystems propose a conceptual framework and from systematic literature review of 65 articles	**Ecosystem Structure:** – examination of the components proposed in the conceptual framework have been applied in developed and developing counties
(Pittaway and Autio, 2017)	– Developed a theoretical foundation for customers' value co-creation in platform ecosystems from a review of 250 articles	**Innovation Ecosystems Business models:** – focus on business model dynamics when it comes to ecosystems – expansion of theoretical model that was introduced – theorising customer involvement in in value creation
(Adner, 2017)	– Outlined formation of innovation ecosystems from structuralist approach - "ecosystem as structure" and "ecosystem as affiliation" perspectives	**Ecosystem Analysis:** – understand what defines industry boundaries – capturing data across multiple actors **Ecosystem Management**: – how authority changes through interactions of internal and external partners – role of institutions, regulators, and influencers such as professional associations in creating context
(Järvi & Kortelainen, 2017)	– Review of empirical 72 articles on ecosystems in a business context	**Ecosystem Analysis:** – use of network analysis and visualisation in studies can assist to understand the structure of ecosystem these interconnections and interdependencies – new research methodologies are needed to capture the essential nature ecosystems research e.g, simulation and agent-based modelling **Ecosystem Governance**: – align innovation strategies with more than one ecosystem **Theory building**: – establish a typology of different types of ecosystems and their conceptual underpinning to have the same referral point
(Jacobides *et al.*, 2018)	– Considered when and why ecosystems emerge and what makes them distinct from other governance mechanisms – Emphasised a platform perspective on researching ecosystems	**Ecosystem Coordination:** – investigate modularity in ecosystem emergence **Ecosystem Collaboration:** – understanding which attitudes and approaches enable the identification and then success of new ecosystems, and which might lead to their demise – investigate empirical focus from *within-ecosystem* to *across-ecosystem* dynamics, as they are likely to influence each other **Ecosystem Value creation/capture:** – assessing how the different types of complementarity play out can also highlight some of the underlying mechanisms of value creation and capture in and across ecosystems – test resilience of ecosystems through modular complementarities **Ecosystem Governance and regulation:** – understand how actors achieve complementarities at the ecosystem level
(Gomes *et al.*, 2018)	Identified themes for innovation ecosystems research and relationships of literature from a review of 125 articles to trace how the concept has evolved	**Technological, Activity and Value architecture:** – how an actor leads an ecosystem – how to integrate supply chain and industry platforms – circumstances under which a firm should build an industry platform **Ecosystem Definition:** – understand clear definition of the ecosystem construct still lacking **Ecosystem Value Creation:** – understand how to bring value creations at the centre of strategic management and tool development is created and delivered within the ecosystem – how do new ventures influence the ecosystem? **Ecosystem Management:** – understand how firms manage partners in an ecosystem, e.g. how to manage innovation challenges across the ecosystem; how to manage the innovation integration across the ecosystem

Reviewer	Review Description and Purpose	Identified Research gaps
(Bogers *et al.*, 2019)	– Introduced a new definition of innovation ecosystem from a review of 300 articles – Provided research opportunities	**Ecosystem Analysis:** – studying the core ecosystem constructs and which part of the definition is being studied – using public data to exemplify value creation e.g company revenues **Ecosystem Value creation and capture**: – mechanisms to capture ecosystem value for individual actors **Ecosystem Governance**: – what distinguishes ecosystems from other forms of governance – operationalisation and measurement of complementarities – establish systematic relationship between actors
(Suominen *et al.*, 2019)	– Study traced the innovation ecosystems concept, definition and the structures aligned with the construct from 427 research articles – Used co-citation analysis	**Ecosystem Analysis:** – researchers to expose theoretical groundings of research – understand how competition and collaboration within platform ecosystems change – look at the capabilities and skills needed to manage platforms and their ecosystems – investigate the kinds of roles are essential in an ecosystem and how they change over time – have unified theory of ecosystems
Granstrand & Holgersson, 2019	– Gave a synthesised definition for innovation ecosystems from 22 articles from innovation systems and ecosystems research	**Ecosystem Analysis:** – usage of game theory in cooperative and competitive dynamics of the ecosystem – balancing of value creation with complementary assets
(Autio & Thomas, 2019)	– Investigated value co-creation in ecosystems across Strategic management, Service Marketing and Information systems	**Ecosystem Analysis:** – Development of frameworks to better understand digital ecosystems – Consider using social exchange theory and institutional theory in understanding ecosystems **Ecosystem Value co-creation and capture**: – Defining boundaries in service ecosystems **Ecosystem Governance**: – Understanding non-contractual governance
(Thomas & Autio, 2020)	– Review the ecosystem concept application to overlapping phenomena – Highlight key sources of terminological and conceptual inconsistencies	**Ecosystem Emergence:** – Understand emergence in terms of spatially and non-spatially confined ecosystems **Ecosystem Actor Competition**: – Understand how ecosystems compete and comparing dynamics between spatially and non-spatially confined ecosystems **Ecosystem Coevolution**: – How do ecosystems change? Looking at internal and external factors **Ecosystem Resilience**: – Understanding how ecosystems survive external shocks and how governance also appropriately aids the ecosystem to continually produce outputs

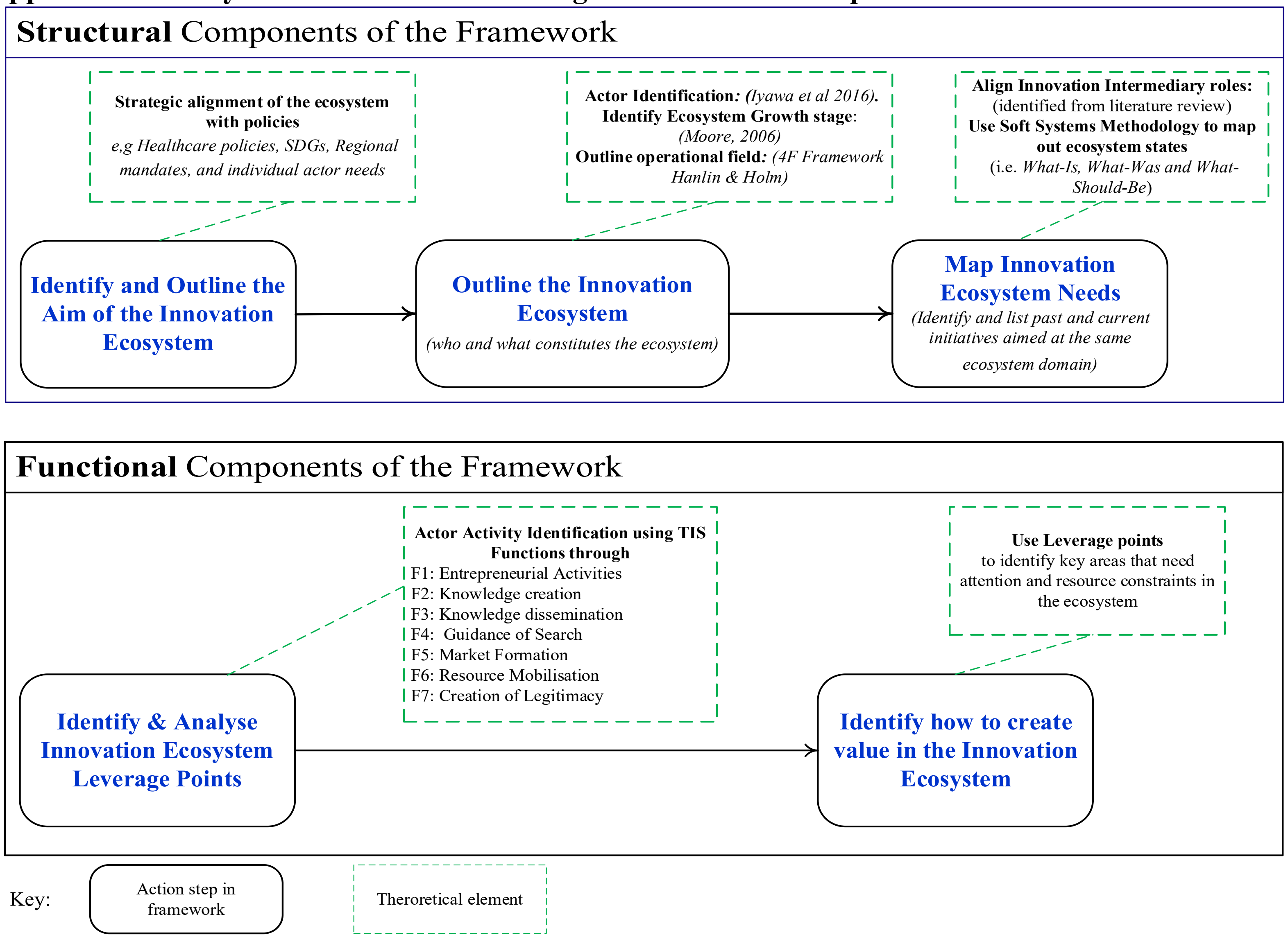
Appendix B: Innovation intermediation Review Articles

Table A.2: Innovation intermediation review articles

	Title	Author	Year	Methodology
1	Building bridges for innovation: the role of consultants in technology transfer	(Bessant and Rush, 1995)	1995	Descriptive Case Study
2	Roles of Systemic Intermediaries in Transition Processes	(van Lente et al., 2020)	2003	Qualitative Case Study
3	Intermediation and the role of intermediaries in innovation	(Howells, 2006)	2006	Qualitative Case Study
4	Matching demand and supply in the agricultural knowledge infrastructure: Experiences with innovation intermediaries	(Klerkx and Leeuwis, 2008)	2008	Qualitative Case Study
5	Intermediaries, Users And Social Learning In Technological Innovation	(Stewart and Hyysalo, 2008)	2008	Literature Review
6	Bridge leadership: a case study of leadership in a bridging organization	(McMullen and Adobor, 2011)	2010	Qualitative Case Study
7	InnovationXchange: A case study in innovation intermediation	(Håkanson et al., 2011)	2011	Qualitative Case Study
8	Performance and Potential of Open Innovation Intermediaries	(Hossain, 2012)	2012	Literature Review
9	How do innovation intermediaries facilitate knowledge spillovers within industrial clusters? A knowledge-processing perspective	(Guo and Guo, 2013).	2013	Qualitative Case Study
10	Linking Entities in Knowledge Transfer: The Innovation Intermediaries	(Abbate et al., 2013)	2013	Literature Review
11	Rethinking the role of intermediaries as an architect of collective exploration and creation of knowledge in open innovation	(Agogué et al., 2013)	2013	Qualitative Case Study
12	Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme	(Kilelu et al., 2013)	2013	Qualitative Case Study
13	The interaction of multiple champions in orchestrating innovation networks: Conflicts and complementarities	(Klerkx and Aarts, 2013)	2013	Qualitative
14	Communication for Rural Innovation Rethinking Agricultural Extension	(Leeuwis, 2013)	2013	Mixed Methods
15	The Role of Innovation Intermediaries in Innovation Systems	(Nilsson and Sia-Ljungström, 2013)	2013	Qualitative Case Study
16	An organizational competence model for innovation intermediaries	(Janssen et al., 2014)	2014	Comparative Case Study
17	Government-affiliated intermediary organisations as actors in system-level transitions	(Kivimaa, 2014)	2014	Comparative Case Study
18	Architectural Leverage: Putting Platforms in Context	(van Lente et al., 2003)	2014	Literature Review
19	Analysis of Open Innovation Intermediaries Platforms by Considering the Smart Service System Perspective	(Abbate et al., 2015)	2015	Literature Review
20	Intermediaries to foster the implementation of innovative land management practice for ecosystem service provision – A new role for researchers	(Schröter et al., 2015)	2015	Qualitative Case Study
21	National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature	(van Welie et al., 2020)	2015	Literature Review
22	An agent-mediated knowledge-in-motion model	(Datta, 2007)	2016	Literature Review
23	Living labs: Implementing open innovation in the public sector	(Gascó, 2017)	2016	Qualitative Case Study
24	The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs	(Hakkarainen and Hyysalo, 2016)	2016	Qualitative Case Study
25	Innovation Intermediaries in Technological Alliances	(Sovacool et al., 2020)	2016	Quantitative Case Study
26	The Role of Innovation Intermediaries in Firm-Innovation Community Collaboration: Navigating the Membership Paradox	(Lauritzen Ghita Dragsdahl, 2017)	2017	Qualitative Case Study
27	Creating innovative zero carbon homes in the United Kingdom — Intermediaries and champions in building projects	(Martiskainen and Kivimaa, 2018)	2017	Qualitative Case Study
28	Innovation, low energy buildings and intermediaries in Europe: systematic case study review	(Kivimaa and Martiskainen, 2018)	2018	Literature Review
29	The role of universities in the knowledge management of smart city projects	(Ardito et al., 2019)	2018	Qualitative Case Study

	Title	Author	Year	Methodology
30	Innovation intermediaries and collaboration: Knowledge–based practices and internal value creation	(De Silva et al., 2018)	2018	Mixed-methods
31	Towards Combining the Innovation Ecosystem Concept with Intermediary Approach to Regional Innovation Development	(Gamidullaeva, 2018)	2018	Qualitative Case Study
32	Roles of intermediaries in supporting eco-innovation	(Kanda et al., 2018)	2018	Qualitative Case Study
33	An intermediary approach to technological innovation systems (TIS)—The case of the cleantech sector in Finland	(Lukkarinen et al., 2018)	2018	Qualitative Case Study
34	Innovation intermediation in a digital age: Comparing public and private new-ICT platforms or agricultural extension in Ghana	(Munthali et al., 2018)	2018	Qualitative Case Study
35	Open Service Innovation: The Role of Intermediary Capabilities	(Randhawa et al., 2018)	2018	Qualitative Case Study
36	Knowledge co-creation in Open processes, tools and services	(Abbate et al., 2019)	2019	Qualitative Case Study
37	An energy leap? Business model innovation and intermediation in the 'Energiesprong' retrofit initiative	(Brown et al., 2019)	2019	Qualitative Case Study
38	A technological innovation systems approach to analyse the roles of intermediaries in eco-innovation	(Kanda et al., 2019)	2019	Qualitative Case Study
39	Diffusion intermediaries: A taxonomy based on renewable electricity technology in Sweden	(Bergek, 2020)	2020	Literature Review
40	Guides or gatekeepers? Incumbent-oriented transition intermediaries in a low-carbon era	(Sovacool et al., 2020)	2020	Qualitative Case Study
41	Positioning of systemic intermediaries in sustainability transitions: Between storylines and speech acts	(Watkins et al., 2015)	2020	Qualitative Case Study
42	Innovation system formation in international development cooperation: The role of intermediaries in urban sanitation	(Weng, 2017)	2020	Qualitative Case Study

Appendix C: Ecosystem Evolution and Emergence Framework Aspects



Appendix D: MAMA and MomConnect Case References

D.1 MAMA References

Title	Author(s)	Type of Publication	Year
1. Adapting educational messages for partners of pregnant women for use in mobile health technologies (mHealth)	Lívia Pimenta Bonifácio *et.al*	Research Paper	2019
2. Implementing the Mobile Alliance for Maternal Action Approach: Lessons from Country Programs: Bangladesh, South Africa, India and Nigeria		Project Report	
3. A Qualitative User Study of a Maternal Text Message based mHealth Intervention: MAMA South Africa	Jesse Coleman *et.al*	Journal Paper	2019
4. The Elusive Path Toward Measuring Health Outcomes: Lessons Learned From a Pseudo-Randomized Controlled Trial of a Large-Scale Mobile Health Initiative	Patricia Mechael *et.al*	Journal Paper	2019
5. Monitoring Mama: Gauging The Impact Of Mama South Africa	Jesse Coleman	Journal Paper	2013
6. Effectiveness of an SMS-based maternal mHealth intervention to improve clinical outcomes of HIV positive pregnant women	Jesse Coleman *et.al*	Journal Paper	2017
7. Mobile Health Apps in OB-GYN-Embedded Psychiatric Care: Commentary	Aydan Mehralizade *et.al*	Journal Paper	2017
8. MAMA South Africa: putting the power of health in every mama's hand. World Health Organization.	World Health Organisation	Technical Report	2013
9. Supporting pregnant women and new mothers in South Africa: cell-life's MAMA SMS	World Health Organisation	Technical Report	2013
10. Lessons from Country Programs Implementing the Mobile Alliance for Maternal Action Programs in Bangladesh, South Africa, India and Nigeria, 2010–2016	Jhpiego	Technical Report	2017
11. The Mobile Alliance for Maternal Action Text Message–Based mHealth Intervention for Maternal Care in South Africa: Qualitative User Study	Jesse Coleman *et.al*	Journal article	2020
12. Mobile Alliance for Maternal Action (MAMA) Lessons Learned	Radha *et.al*	Digital Square	2018

D.2 MomConnect References

Title	Author(s)	Type of Publication	Year
1. Exploring Innovation for Inclusive Development Dynamics from an Innovation Systems Perspective	Edward van der Merwe	MSc Thesis	2016
2. Mobile health messaging service and helpdesk for South African mothers (MomConnect): history, successes and challenges	Peter Barron *et.al*	Journal Article	2017
3. Using basic technology – and corporate social responsibility – to save lives	Chris Bateman	Journal Article	2014
4. Self-enrolment antenatal health promotion data as an adjunct to maternal clinical information systems in the Western Cape Province of South Africa	Alexa Heekes *et.al*.	Journal Article	2018
5. Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure	Amnesty E LeFevre *et.al.*	Journal Article	2018
6. Digital health vision: could MomConnect provide a pragmatic starting point for achieving universal health coverage in South Africa and elsewhere?	Garrett Livingston Mehl *et.al*	Journal Article	2017
7. Towards a framework for technology platform design, development and implementation in South African health: preliminary validation	Hilde Herman *et.al*	Conference Article	2018
8. Understanding the influence of the MomConnect programme on antenatal and postnatal care service utilisation in two South African provinces: a realist evaluation protocol	Eveline M Kabongo *et.al*	Journal Article	2019
9. Using technology to improve access to healthcare: The case of the MomConnect programme in South Africa	Sara S Grobbelaar & Mauricio Uriona-Maldonado	Journal Article	2019
10. Smartphone usage and preferences among postpartum HIV-positive women in South Africa	Phepo Mogoba *et.al*	Journal Article	2019
11. Achieving scale, sustainability and impact: a donor perspective on a mobile health messaging service and help desk (MomConnect) for South African mothers	Joanne Peter	Journal Article	2017
12. Taking digital health innovation to scale in South Africa: ten lessons from MomConnect	Joanne Peter *et.al*	Journal Article	2017
13. An Activity Theory Approach to Affordance Actualisation In mHealth: The Case Of MomConnect	Brendon Wolff-Piggott & Ulrike Rivett	Research Paper	2016
14. Designing for scale: optimising the health information system architecture for mobile maternal health messaging in South Africa (MomConnect)	Christopher Seebregts	Journal Article	2017
15. User assessments and the use of information from MomConnect, a mobile phone text-based information service, by pregnant women and new mothers in South Africa	Donald Skinner *et.al*	Journal Article	2017
16. The design and development of technology platforms in a developing country healthcare context from an ecosystem perspective	Hilde Herman *et.al*	Journal Article	2020
17. The status of vaccine availability and associated factors in Tshwane government clinics	N J Ngcobo	Journal Article	2017
18. The-Momconnect-Nurses-and-Midwives-Support-Platform-NurseConnect-A-qualitative-process-evaluation	Alex Emilio Fischer *et.al*	Journal Article	2019
19. The MomConnect mHealth initiative in South Africa: Early impact on the supply side of MCH services	Peter Barron *et.al*	Journal Article	2016
20. The MomConnect helpdesk: how an interactive mobile messaging programme is used by mothers in South Africa	Khou Xiong	Journal Article	2018

Appendix E: Ethical Clearance

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

APPROVED WITH STIPULATIONS
REC Humanities New Application Form

21 June 2018

Project number: ING-2018-6442

Project title: Developing Healthcare Innovation Ecosystems: The Context of Value Co-Creation through Innovation Intermediaries

Dear Miss Chipo Ngongoni

Your REC Humanities New Application Form submitted on 5 May 2018 was reviewed by the REC: Humanities and approved with stipulations.

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
21 June 2018	20 June 2021

REC STIPULATIONS:

The researcher may proceed with the envisaged research provided that the following stipulations, relevant to the approval of the project are adhered to or addressed:

The researcher is reminded to obtain permission from participating organisations/institutions before data collection commences. Proof of permission should be uploaded to the REC record once all permissions are in place. [ACTION REQUIRED]

HOW TO RESPOND:

Some of these stipulations may require your response. Where a response is required, you must respond to the REC within six (6) months of the date of this letter. Your approval would expire automatically should your response not be received by the REC within 6 months of the date of this letter.

Your response (and all changes requested) must be done directly on the electronic application form on the Infonetica system: https://applyethics.sun.ac.za/Project/Index/6721

Where revision to supporting documents is required, please ensure that you replace all outdated documents on your application form with the revised versions. Please respond to the stipulations in a separate cover letter titled "**Response to REC stipulations**" and attach the cover letter in the section **Additional Information and Documents**.

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (6442) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further

Page 1 of 3

Appendix F: Interview Guides

F.1 TIS Functions related Interview Guide for Implementers

Section 1 –Profile

(*this is the background and expertise of the interview candidate*)

- Can you give me an overview of your skillset and current organisation?
- What is your position is in the DHIS2 based project and community?
- When did you join this project?
- How would you describe this innovation ecosystem in terms of actors and composition?
- What is the purpose/vision/core interaction of this ecosystem?

Section 2 – Healthcare Innovation Ecosystem dynamics

(*this looks at various Technology Innovation System evolutionary processes that are taking part in the Innovation ecosystem. Take note the innovation ecosystem is the DHIS2 platform and community)*

Process 1: Entrepreneurial activities

- Have you ever had any new ideas of how to implement a new aspect in an intervention?
- Are there any processes and protocols in place for suggesting and capturing new ideas on process improvements?
- "What is the extent of involvement of the intermediary organisation (e.g MoH and NPOs) in idea generation and entrepreneurial activities amongst developers?
- What barriers exist towards the inclusion of such ideas?"
- Are there any incentives in place to spur entrepreneurial thinking in the organisation? In the ecosystem?
- Do you have any other suggestions to how such ideas can be captures and integrated into the DHIS2 local implementations?

Process 2: Knowledge development

- Which type of knowledge exists that can be utilised by the implementers of different healthcare interventions? How is this documented and communicated?
- How may this be included in the innovation process?
- What are the major sources of knowledge?
- Do ecosystem actors possess the capabilities and capacities to acquire relevant contextual knowledge?
- Are the users/ marginalised actors/beneficiaries utilised as knowledge providers? If so, how, and how do they benefit?
- Is the generated knowledge sufficient in quality and quantity?
- Does collaboration exist among formal and informal research organisations? E.g Local Universities and Research organisations
- Are marginalised solutions developed considering the healthcare strategy or health information system national strategies?
- How is this incorporated in the value offering in terms of acceptability, accessibility and affordability?
- Are there local technical training and guidance initiatives for local organisations or businesses or individuals who may want to engage with DHIS2 solutions?
- Are there existing innovation ecosystems policies and institutions to provide empowerment and capabilities for local organisations? Are they supported by specific programmes?

Process 3: Knowledge diffusion

- Are there established linkages and local environments where spaces and places exist for DHIS2 specialists and implementers to engage (e.g. roundtables, intermediaries)? Important, as pockets of knowledge often exist that remains in isolation.
- Which knowledge diffusion channels exist for DHIS2 platforms and interventions knowledge and research?
- Does the knowledge correspond to the needs of the ecosystem?
- Is the knowledge of the problems the implementers are facing making it to top decision-makers?
- Is there provision of knowledge in local language?
- Does the system allow for removing inhibiting factors in communication?

Process 4: Guidance of search

- Do you take part in the healthcare strategy and planning sessions for DHIS2 related interventions and programs?
- Is there a structured nation-wide approach?
- Which indicators are used to measure the outcomes of the specific innovation activities?
- What are the major constraints for the innovation ecosystem?

Process 5: Market formation

- What are the institutional constraints/barriers for the local innovation ecosystems with relation to HISP Oslo?
- Which current market interventions exist to shape the way interventions are undertaken?
- Which institutional incentives exist?

Process 6: Resource Mobilisation

- Are there local financial and supportive mechanisms that provide guidance and support for actors involved in and creating innovation ecosystems (e.g. group financing, business development support)?
- Do these resources correspond to system needs?
- Is there sufficient access to resources? (e.g. donor funding, government funding and private sector funding)
- Technological capabilities – which current technological infrastructure exists in the innovation ecosystem that supports the innovation being implemented?
- What are the major barriers to gain access to target marginalised end users? What are the main infrastructural barriers and methods to overcome these?
- Is there adequate public funding?
- Is it spent in the right areas?
-

Process 7: Creation of Legitimacy

- To what extent is the innovation part of government delivery (e.g. specific ict forming of government services)? government often provides legitimacy around projects when involved and may serve as an important actor from which to draw resources.
- Is the private sector showing commitment to advance the sector?
- where is the resistance to change coming from?
- who is the main contributor to the resistance?

Additional Perspectives

- From your experience, what would you say is the most crucial aspect for the success of the ecosystem?
- What do you think can be done to improve participation in the ecosystem by actors?
- What do you think should be done to increase the collaboration of other actors in the ecosystem?
- Where would you like the most guidance in terms of governance of your participation and ecosystem?

F.2 TIS Functions related Interview Guide for HMIS Officers

Section 1 –Profile

(*this is the background and expertise of the interview candidate***)**

- Can you give me an overview of your skillset and current organisation?
- What is your position is in the DHIS 2 based project and community?
- When did you start evaluating DHIS 2?
- What is the purpose/vision/core reason for interaction in the projects that you have evaluated?

Section 2 – Healthcare Innovation Ecosystem dynamics

(*this looks at various Technology Innovation System evolutionary processes that are taking part in the Innovation ecosystem. Take note the innovation ecosystem is the DHIS 2 platform and community.*

The questions in this section align with the organisations that you have evaluated aligned with the implementation and maintenance of healthcare initiatives around DHIS 2

Process 1: Entrepreneurial activities

- Are there any processes and protocols in place of how you communicate with DHIS 2 developers?
- Are there any processes and protocols in place for suggesting and capturing new ideas on process improvements?
- What is the extent of involvement of the intermediary organisation (e.g MoH and NPOs) in idea generation and entrepreneurial activities amongst HMIS officers and developers?
- What barriers exist towards the inclusion of such ideas?
- Are there any incentives in place to spur entrepreneurial thinking in the organisation? In the innovation ecosystem?
- Do you have any other suggestions to how such ideas can be captures and integrated into the DHIS 2 local implementations?

Process 2: Knowledge development

- Which type of knowledge exists that can be utilised by the implementers of different healthcare interventions?
- How is this documented and communicated? What is your preferred way of communicating?
- How may this be included in the innovation process?
- What are the major sources of knowledge?
- Do ecosystem actors possess the capabilities and capacities to acquire relevant contextual knowledge?
- Are the users/ marginalised actors/beneficiaries utilised as knowledge providers? If so, how, and how do they benefit?
- Is the generated knowledge sufficient in quality and quantity?
- Does collaboration exist among formal and informal research organisations? E.g Local Universities and Research organisations
- Are marginalised solutions developed considering the healthcare strategy or health information system national strategies?
- How is this incorporated in the value offering in terms of acceptability, accessibility and affordability?
- Are there local technical training and guidance initiatives for local organisations or businesses or individuals who may want to engage with DHIS 2 solutions?
- Are there existing innovation ecosystems policies and institutions to provide empowerment and capabilities for local organisations? Are they supported by specific programmes?

Process 3: Knowledge diffusion

- Are there established linkages and local environments where spaces and places exist for DHIS 2 specialists and implementers to engage (e.g. roundtables, intermediaries)? Important, as pockets of knowledge often exist that remains in isolation.
- Which knowledge diffusion channels exist for DHIS 2 platforms and interventions knowledge and research? E.g WhatsApp, log books
- Does the knowledge correspond to the needs of the ecosystem?
- Is the knowledge of the problems the implementers are facing making it to top decision-makers?
- Is there provision of knowledge in local language?
- Does the system allow for removing inhibiting factors in communication?

Process 4: Guidance of search

- Do you take part in the healthcare strategy and planning sessions for DHIS2 related interventions and programs?
- Is there a structured nation-wide approach?
- Which indicators are used to measure the outcomes of the specific innovation activities?
- What are the major constraints for the innovation ecosystem?

Process 5: Market formation

- Have you ever had any training or communication with HISP Oslo?
- Which current market interventions exist to shape the way interventions are undertaken?
- Which institutional incentives exist?

Process 6: Resource Mobilisation

- Are there local financial and supportive mechanisms that provide guidance and support for actors involved in and creating innovation ecosystems (e.g. group financing, business development support)?
- Do these resources correspond to system needs?
- Is there sufficient access to resources? (e.g. donor funding, government funding and private sector funding)
- Technological capabilities – which current technological infrastructure exists in the innovation ecosystem that supports the innovation being implemented?
- What are the major barriers to gain access to target marginalised end users? What are the main infrastructural barriers and methods to overcome these?
- Is there adequate public funding?
- Is it spent in the right areas?
-

Process 7: Creation of Legitimacy

- To what extent is the innovation part of government delivery (e.g. specific ict forming of government services)? government often provides legitimacy around projects when involved and may serve as an important actor from which to draw resources.
- Is the private sector showing commitment to advance the sector?

- where is the resistance to change coming from?
- who is the main contributor to the resistance?

Additional Perspectives

- From your experience, what would you say is the most crucial aspect for the success of the ecosystem?
- What do you think can be done to improve participation in the ecosystem by actors?
- What do you think should be done to increase the collaboration of other actors in the ecosystem?
- Where would you like the most guidance in terms of governance of your participation and ecosystem?

F.3 TIS Functions related Interview Guide for Evaluators

Section 1 –Profile

(*this is the background and expertise of the interview candidate*)

Can you give me an overview of your skillset and current organisation?
What is your position is in the DHIS 2 based project and community?
When did you start evaluating DHIS 2?
What is the purpose/vision/core reason for interaction in the projects that you have evaluated?

Section 2 – Healthcare Innovation Ecosystem dynamics

(*this looks at various Technology Innovation System evolutionary processes that are taking part in the Innovation ecosystem. Take note the innovation ecosystem is the DHIS 2 platform and community.*

The questions in this section align with the organisations that you have evaluated aligned with the implementation and maintenance of healthcare initiatives around DHIS 2

Process 1: Entrepreneurial activities

- Are there any processes and protocols in place of how DHIS 2 developers capture and implement a new aspect in an intervention? - ideally outside the scope of projects
- Are there any processes and protocols in place for suggesting and capturing new ideas on process improvements?
- What is the extent of involvement of the intermediary organisation (e.g MoH and NPOs) in idea generation and entrepreneurial activities amongst developers?
- What barriers exist towards the inclusion of such ideas?
- Are there any incentives in place to spur entrepreneurial thinking in the organisation? In the innovation ecosystem?
- Do you have any other suggestions to how such ideas can be captured and integrated into the DHIS 2 local implementations?

Process 2: Knowledge development

- Which type of knowledge exists that can be utilised by the implementers of different healthcare interventions? E.g is there local documentation, local training material etc
- How is this documented and communicated?
- How may this be included in the innovation process?
- What are the major sources of knowledge?
- Do ecosystem actors possess the capabilities and capacities to acquire relevant contextual knowledge?
- Are the users/ marginalised actors/beneficiaries utilised as knowledge providers? If so, how, and how do they benefit?
- Is the generated knowledge sufficient in quality and quantity?
- Does collaboration exist among formal and informal research organisations? E.g Local Universities and Research organisations
- Are marginalised solutions developed considering the healthcare strategy or health information system national strategies?
- How is this incorporated in the value offering in terms of acceptability, accessibility and affordability?
- Are there local technical training and guidance initiatives for local organisations or businesses or individuals who may want to engage with DHIS 2 solutions?
- Are there existing innovation ecosystems policies and institutions to provide empowerment and capabilities for local organisations? Are they supported by specific programmes?

Process 3: Knowledge diffusion

- Are there established linkages and local environments where spaces and places exist for DHIS 2 specialists and implementers to engage (e.g. WhatsApp groups, roundtables, intermediaries)? Important, as pockets of knowledge often exist that remains in isolation.
- Which knowledge diffusion channels exist for DHIS 2 platforms and interventions knowledge and research?
- Does the knowledge correspond to the needs of the ecosystem?
- Is the knowledge of the problems the implementers are facing making it to top decision-makers?
- Is there provision of knowledge in local language?
- Does the system allow for removing inhibiting factors in communication?
- What trainings have you attended?
- Have you trained others?
- Any other training that is important?
- Have you ever used DHIS 2 online training and documentation?

Process 4: Guidance of search

- Do you take part in the healthcare strategy and planning sessions for DHIS2 related interventions and programs?
- Is there a structured nation-wide approach?
- Which indicators are used to measure the outcomes of the specific innovation activities?
- What are the major constraints for the innovation ecosystem?

Process 5: Market formation

- What are the institutional constraints/barriers for the local innovation ecosystems with relation to HISP Oslo?
- Which current market interventions exist to shape the way interventions are undertaken?
- Which institutional incentives exist?

Process 6: Resource Mobilisation

- Are there local financial and supportive mechanisms that provide guidance and support for actors involved in and creating innovation ecosystems (e.g. group financing, business development support)?
- Do these resources correspond to system needs?
- Is there sufficient access to resources? (e.g. donor funding, government funding and private sector funding)
- Technological capabilities – which current technological infrastructure exists in the innovation ecosystem that supports the innovation being implemented?
- What are the major barriers to gain access to target marginalised end users? What are the main infrastructural barriers and methods to overcome these?
- Is there adequate public funding?
- Is it spent in the right areas?
-

Process 7: Creation of Legitimacy

- To what extent is the innovation part of government delivery (e.g. specific ict forming of government services)? government often provides legitimacy around projects when involved and may serve as an important actor from which to draw resources.
- Is the private sector showing commitment to advance the sector?
- where is the resistance to change coming from?
- who is the main contributor to the resistance?

Additional Perspectives

- From your experience, what would you say is the most crucial aspect for the success of the ecosystem?
- What do you think can be done to improve participation in the ecosystem by actors?
- What do you think should be done to increase the collaboration of other actors in the ecosystem?
- Where would you like the most guidance in terms of governance of your participation and ecosystem?

F.4 Integrated Functions and Interview Questions

TIS Process	Indicators	Aligned with the study
Process 1: Entrepreneurial activities	1.1 Idea Generation	Have you ever had any new ideas of how to implement a new aspect in an intervention?
	1.2 Idea Capture	Are there any processes and protocols in place for suggesting and capturing new ideas on process improvements?
	1.3 Depth of Involvement	What is the extent of involvement of the intermediary organisation (e.g MOH and NPOs) in idea generation and entrepreneurial activities amongst developers? What barriers exist towards the inclusion of of such ideas?
	1.4 Incentives	Are there any incentives in place to spur entrepreneurial thinking in the organisation? In the ecosystem?
	1.5 Suggestions	Do you have any other suggestions to how such ideas can be captures and integrated into the DHIS2 local implementations?
Process 2: Knowledge development	2.1 Local knowledge	Which type of knowledge exists that can be utilised by the implementers of different healthcare interventions? How is this documented and communicated ? How may this be included in the innovation process?
	2.2 Origin of knowledge	What are the major sources of knowledge? Do ecosystem actors possess the capabilities and capacities to acquire relevant contextual knowledge? Are the users/ marginalised actors/beneficiaries utilised as knowledge providers? If so, how, and how do they benefit?
	2.3 Research capacity	Is the generated knowledge sufficient in quality and quantity?
	2.4 Research collaboration	Does collaboration exist among formal and informal research organisations? E.g Local Universities and Research organisations
	2.5 Focus of knowledge development	Are marginalised solutions developed considering the healthcare strategy or health information system national strategies? How is this incorporated in the value offering in terms of acceptability, accessibility and affordability?
	2.6 Training and development of capabilities/capacity	Are there local technical training and guidance initiatives for local organisations or businesses or individuals who may want to engage with DHIS2 solutions?
		Have you been involved in training others
	2.7 Institutional empowerment	Are there existing innovation ecosystems policies and institutions to provide empowerment and capabilities for local organisations? Are they supported by specific programmes?

Process 3: Knowledge diffusion	3.1 Knowledge platforms and boundary spanning	Are there established linkages and local environments where spaces and places exist for DHIS2 specialists and implementers to engage (e.g. Roundtables, intermediaries)? Important, as pockets of knowledge often exist that remains in isolation. Which knowledge diffusion channels exist for DHIS2 platforms and interventions knowledge and research?
	3.2 Depth of knowledge	Does the knowledge correspond to the needs of the ecosystem?
	3.3 Knowledge influence trajectory	Is the knowledge of the problems the implementers are facing making it to top decision-makers?
	3.4 Local language incorporation	Is there provision of knowledge in local language?
Process 4: Guidance of search	4.1 Clear shared vision and goal	Do you take part in the healthcare strategy and planning sessions for DHIS2 related interventions and programs? Is there a structured nation-wide approach?
	4.2 Outcome indicators	Which indicators are used to measure the outcomes of the specific innovation activities?
	4.3 Recognised constraints	What are the major constraints for the innovation ecosystem?
Process 5: Market formation	5.1 Institutional barriers	What are the institutional constraints/barriers for the local innovation ecosystems with relation to HISP Oslo?
	5.2 Existing market interventions	Which current market interventions exist to shape the way interventions are undertaken?
	5.3 Institutional incentives	Which institutional incentives exist?
Process 6: Resource mobilisation	6.1 Financial mechanisms	Are there local financial and supportive mechanisms that provide guidance and support for actors involved in and creating innovation ecosystems (e.g. Group financing, business development support)? Do these resources correspond to system needs?
	6.2 Access to resources	Is there sufficient access to resources? (e.g. Donor funding, government funding and private sector funding)
	6.3 Technological capabilities	Technological capabilities – which current technological infrastructure exists in the innovation ecosystem that supports the innovation being implemented?
	6.4 Access to informal communities	What are the major barriers to gain access to target marginalised end users? What are the main infrastructural barriers and methods to overcome these?
	6.6 Public funding	Is there adequate public funding? Is it spent in the right areas?
Process 7: Creation of legitimacy	7.1 Government involvement/commitment	To what extent is the innovation part of government delivery (e.g. Specific ict forming of government services)? Government often provides legitimacy around projects when involved and may serve as an important actor from which to draw resources.
	7.2 Private sector commitment	Is the private sector showing commitment to advance the sector?
	7.3 Resistance to change	Where is the resistance to change coming from? Who is the main contributor to the resistance?

Appendix G: Integrative aspect of Framework

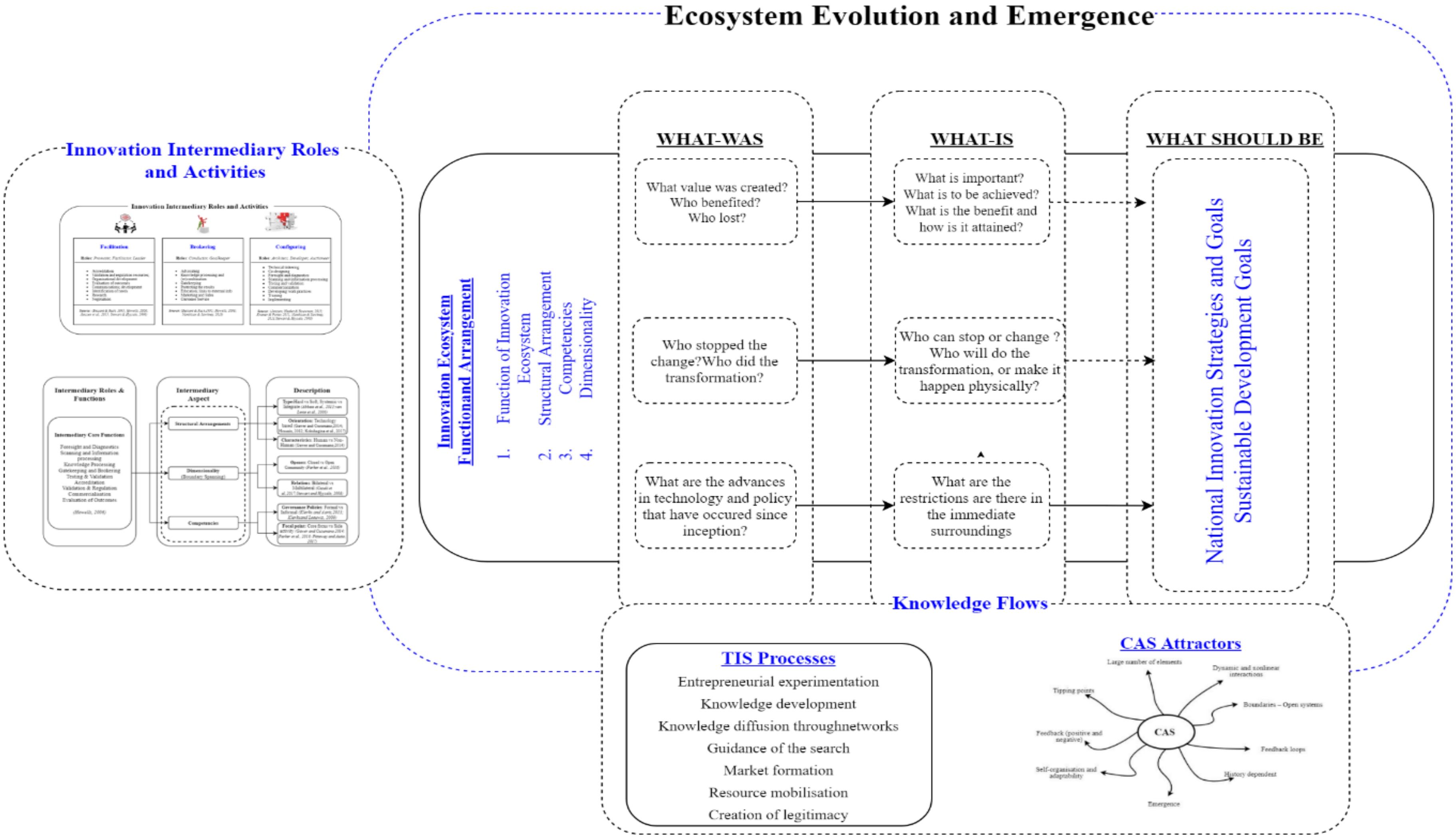


Figure A.1: Integration of framework subsystems

Appendix H: MAMA SA Listed Events

Table A.3: Birth Stage MAMA Event database

Life stage	Functions	*MAMA Key Event and Effect on Ecosystem*	*Effect on Ecosystem*	*Key Ecosystem Activity*	*Attractor Category*
Birth	**F1-ENT:** Entrepreneurial experimentation	Experimented with business model for sustainability	(+)	Business Model Experimentation	***Running costs***
		Finding best ways to disseminate information to pregnant and post-partum women	(+)	Information dissemination channels	***Accessibility to End-users***
		5 channels for accessing platform to determine best way	(+) / (-)	Number of information channels	***Accessibility to End-users***
		Migration from paper based to computerised system increase had high implementation costs	(+) / (-)	Technology choice and migration	***Technology usages***
		Users using mobisite for chatting instead of getting pregnancy messages	(-)	Misuse of technology	***Policing the platform***
		Users dropped off service once cost was associated with use	(-)	Costs of use	***Accessibility to End-users***
	F2-KDev: Knowledge development	MAMA was being undertaken in Bangladesh, India and Nigeria and MAMA SA was taking learnings from those projects	(-)	Learning from other projects	***Learning from the past***
		University students through Cell-Life undertook research studies for MAMA	(+)	Access to workforce from partners	***Research institutions collaborations***
		University collaboration with Research Contracts and Innovation Centre	(+)	Collaboration with universities	***Research institutions collaborations***
		Content creation undertaken by the Baby Center	(+) / (-)	Content creation (rom international partners)	***Content curation***
		No formal procedure for signing up to the platform	(-)	User signup procedure (Formal/informal)	***Accessibility to End-users***
		Analysing the best channel to get user traction	(+)	Selection of information channel	***Technology usages***
	F3-KDif: Knowledge diffusion	Cell-Life handed over research to the Research Contracts and Innovation Centre	(+)	Handover of tangible and intangible project knowledge	***Project knowledge repository***
		MAMA was being undertaken in Bangladesh, India and Nigeria and MAMA SA was taking learnings from those projects	(+)	Global network of programs	***Learn from other projects (past)***
		Communication was one-way pushing message to users	(-)	One way communication	***Feedback mechanisms***
		MAMA used Vodacom Operator deck to mitigate costs	(+)	User costs carried by partner organisations	***Running costs***
	F4-GS: Guidance of search	There was no core innovation intermediary	(-)	Group of core facilitators	***Core Facilitator***
		Lack of Signups due to payment for platform	(-)	End-users made to pay	***Platform Network Effects***
	F5-MF: Market formation	Vodacom Foundation offers to support 6000 women	(+)	Partners provide early adopters	***Accessibility to End-users***
		Johnson and Johnson offers to fund 2000 women	(+)	Partners fund early adopters	***Running costs /Accessibility to End-users***
		5 Channels for user signups	(+) / (-)	Technology channels to reach actors	***Accessibility to End-users/ Technology maintenance***
		MAMA used Vodacom Operator deck to reach users instantly	(+)	Partners provide early adopters	***Accessibility to End-users***
		MAMA SA had to educate users on the platform	(+)	User education	***Platform usability***
		Users made to pay nominal fee for signups	(-)	End-users made to pay	***Platform Network Effects***
		Migration from paper based to computerised system had administrative burden and data errors	(-)	Technology errors and administrative burden	***Technology usages***
	F6-RM: Resource mobilisation	MAMA used Vodacom platforms for mobi site	(+) / (-)	Use of partner platforms	***Technology formulation/ Accessibility to End-users***
		Program was supported by donor funds	(+)/(-)	Donor funding-lack of full autonomy	***Running costs***
		Human and Technical resources from the University of Cape Town (UCT)	(+)	Collaboration with research organisations as sources of expertise	***Research institutions collaborations***
		CellLife closed down	(-)	Actors exiting the ecosystem	***Research institutions collaborations***
		Local implementers had experience in mobile technology projects	(+)	Use of local implementers	***Technology formulation***
	F7-CL: Creation of legitimacy	Made up of consortium of public-private international partners and local implementers	(+)	Various partner organisations	***Vast core platform creators***

Life stage	Functions	*MAMA Key Event and Effect on Ecosystem*	*Effect on Ecosystem*	*Key Ecosystem Activity*	*Attractor Category*
		University partnerships with UCT and CPUT from companies like Cell-Life	(+)	Inter-university collaborations	***Research institutions collaborations***
		Aligned with NDoH strategic goals	(+)	Aligned with national health strategies	***Strategic goal alignment***

Table A.4: Expansion MAMA Event database

Life stage	Functions	MAMA Key Event and Effect on Ecosystem	Effect on Ecosystem	Key Ecosystem Activity	Attractor Category
Expansion	**F1-ENT:** Entrepreneurial experimentation	Decreased the channels from 5 to 4 channels	(+)	End-user information channels decreased	***Running costs/ Technology formulation***
		Could not truly reflect the number of women who signed up due to a lack of gatekeepers	(-)	No project gatekeepers	***Core Facilitator/ Gatekeepers***
		Utilised open sources platforms like Open Data Kit	(+)	Use of freely available repositories	***Project knowledge repository***
		Investigate ways to generate revenue on the platform for sustainability	(+) / (-)	Business model experimentation	***Running costs/ Business model experimentation***
	F2-KDev: Knowledge development	Analyse dashboards for all channels	(+) / (-)	Collate data across all channels for insights	***Data analytics***
		Undertake interviews with patients and review patient records, conducted exit interviews	(+)	Surveys, review patient records and exit interviews	***Data analytics***
		Hired an employee to internally take role left by Cell-Life after Cell-Life closed down	(-)	Hiring of internal staff closes the ecosystem	***Resource and Skills development / Open ecosystem***
		Aditional costs saw user drop off of 95%	(+)/(-)	End-users made to pay	***Running costs /Platform signups***
		Investigate ways to have gatekeepers for correct target segment to sign up	(+)	Use gatekeepers to access target segment	***Accessibility to End-users***
		Created a MAMA Global Learning Program through TechChange	(+)	Learning program creation from project lessons	***Project knowledge repository***
	F3-KDif: Knowledge diffusion	Need for gatekeepers to ensure correct signup procedures	(+)	Gatekeepers for user signups	***Accessibility to End-users***
		Delivered courses and videos through TechChange	(+)	Internal content curation	***Project knowledge repository***
		Hiring internal staff to maintain the ecosystem	(+)/(-)	Hiring of internal staff closes the ecosystem	***Resource and Skills development / Open ecosystem***
		Use of automated dashbpoards for all channels	(+)/(-)	Automated dashboards	***Data analytics***
	F4-GS: Guidance of search	Offer of free service across all mobile network operators	(+)	Free access to users	***Accessibility to End-users***
	F5-MF: Market formation	More channels opened up the addressable market	(+)	Increase channel with user accessibility	***Technology formulation***
		Looking for advertisers without decreasing user base	(+)	Advertiser on channels	***Running costs***
	F6-RM: Resource mobilisation	Develop inhouse knowledge by hiring employees	(+)	Hiring of internal staff improves knowledge	***Resource and Skills development / Open ecosystem***
		Clash between potential sponsors and donors through co-opetition	(-)	Clash between ecosystem actors	***Core facilitator***
		Addition of all Mobile network operators (increased complexity)	(+) / (-)	Addition of more actors	***Accessibility to End-users/ Resource and Skills development / Open ecosystem***
	F7-CL: Creation of legitimacy	Find ways to for ecosystem actors to legitimise platform through funding	(+)	Funding legitimising platform	***Running costs***

Table A.5: Self-Renewal MAMA Event database

Life stage	Functions	MAMA Key Event and Effect on Ecosystem	Effect on Ecosystem	Key Ecosystem Activity	Attractor Category
Self-Renewal	**F1-ENT:** Entrepreneurial experimentation	Handed over project to NDoH	(+)	Ministry as core facilitator	***Core facilitator***
	F2-KDev: Knowledge development	Shared setup processes with NDoH	(+)	MAMA shared knowledge with NDoH	***Project knowledge repository***
		Evaluated the MAMA projects across all 4 countries using this mHealth Assessment and Planning for Scale (MAPS) toolkit	(+)	Project was evaluated with MAPS toolkit	***Project knowledge repository***
	F3-KDif: Knowledge diffusion	Shared learnings with NDoH	(+)	MAMA shared setup procedure with NDoH	***Project knowledge repository***
		Shared key findings through reports	(+)	Report writing	***Project knowledge repository***
	F4-GS: Guidance of search	Lessons assisted in the starting of the NDoH	(+)	MAMA shared knowledge with NDoH	***Project knowledge repository***
	F6-RM: Resource Mobilisation	Shared the resources with NDoH	(+)	MAMA shared knowledge with NDoH	***Project knowledge repository***
	F7-CL: Creation of legitimacy	Handed over project to NDoH	(+)	Project handover	***Open ecosystem/ Project knowledge repository***

Appendix I: MomConnect Listed Events

Table A.6: Birth MomConnect Event database

Life stage	*Functions*	*MomConnect Key Event and Effect on Ecosystem*	*Effect on Ecosystem*	*Key Ecosystem Activity*	*Attractor Category*
Birth	**F1-ENT:** Entrepreneurial experimentation	Utilise the failures of MAMA as starting points	(+)	Learn from the past projects	***Project knowledge repository***
		Use SABC to publish the program	(+)	Use local broadcaster-advertising initiative	***Advertising ecosystem initiative***
	F2-KDev: Knowledge development	Leverage off learnings from MAMA	(+)	Learn from the past projects	***Project knowledge repository***
		Connected with National pregnancy register, DHIS2	(+)	Ecosystem Architecture connecting to current technology	***Technology formulation***
		Utilised database from the Baby Center	(+)	Use free available repositories	***Project knowledge repository***
	F3-KDif: Knowledge diffusion	Baby Center shares the repository with Non-Profit organisations	(+) / (-)	Share repositories from partners	***Project knowledge repository***
		Nurses used for signups	(+) / (-)	Use gatekeepers for technology	***Accessibility to End-users***
		Use of local programs like Soul City	(+)	Use local broadcaster	***Accessibility to End-users***
	F4-GS: Guidance of search	Use research from MAMA	(+)	Learn from the past projects	***Project knowledge repository***
		Ministry has focal point for leadership	(+) / (-)	NDoH as Innovation Intermediary	***Core facilitator***
	F5-MF: Market formation	Use of local programs like Soul City	(+)	Use local broadcaster-advertising initiative	***Accessibility to End-users***
		Use of 11 local languages	(+)/ (-)	Wide language capabilities	***Accessibility to End-users***
		Two user signup channels	(+)	Focal channels then increase for access	***Technology formulation***
		30+ implementation partners	(+)/ (-)	Use more implementation partners	***Open Ecosystem***
		Use local implementation partners	(+)	Use local ecosystem actors	***Build Local Core ecosystem/ Build a database of experts - CoP***
	F6-RM: Resource mobilisation	Interconnection with other platforms	(+)	Ecosystem Architecture connecting to current technology	***Technology formulation***
		Utilise expertise that had been involved in the MAMA project	(+)	Use expertise from past projects	***Build a database of experts - CoP***
		Utilise international partners	(+) / (-)	Use international partners	***Open Ecosystem***
	F7-CL: Creation of legitimacy	Across all the 11 local languages	(+)	Wide language capabilities	***Accessibility to End-users***
		NDoH created legitimacy for the project	(+)	Select a core intermediary	***Core facilitator***
		Additional platforms like Facebook for advertising platform	(+)	Use partner social media to create legitimacy	***Advertising ecosystem initiative***

Table A.7: Expansion MomConnect Event database

Life stage	*Functions*	*MomConnect Key Event and Effect on Ecosystem*	*Effect on Ecosystem*	*Key Ecosystem Activity*	*Attractor Category*
Expansion	**F1-ENT:** Entrepreneurial experimentation	Experimented with WeChat and Facebook	(+)	Expand to other messaging applications	***Technology formulation***
		MomConnect expanded to WhatsApp channel	(+) / (-)	Customisable technology	***Technology formulation***
		Technological interoperability through integration with National Health System	(+)	Interoperable technology	***Technology formulation***
		MomConnect was used to inform other healthcare disparities such as stockouts	(+)	***Various functions across ecosystem***	***Technology usages***
		Usage of frameworks such as OpenHIM	(+)	***Use free available repositories***	***Technology formulation / Project knowledge repository***
		Helpdesk assisted with feedback mechanisms	(+)	Feedback mechanism in ecosystem	***Feedback Mechanisms***
		Learnt from feedback		Feedback mechanism in ecosystem	***Feedback Mechanisms/ Open ecosystem***
		Dissemination of information increased to 3 channels	(+)/ (-)	Increase of ecosystem actor communication channels	***Open ecosystem / Accessibility to End-users/ Technology formulation***
		Using experienced local implementers	(+)	Use local ecosystem actors with experience	***Build Local Core ecosystem/ Build a database of experts - CoP***
	F4-GS: Guidance of search	International funders	(+)/(-)	Donor funding-lack of full autonomy	***Open Global Ecosystem/ Running costs***
	F5-MF: Market formation	Increasing user base through mandatory sign-ups	(+)	Mandatory user engagement	***Accessibility to End-users***

		NDoH as core facilitator of the project	(+)	Select right intermediary	***Core facilitator***
		Technological advancements opened ways to increase channels	(+)	Environmental and socio-economical advancements	***Technology formulation***
		More data from various platforms	(+)/ (-)	Data from various dashboards	***Data analytics***
	F7-CL: Creation of legitimacy	Having various channels for information dissemination	(+)	Wider user engagement	***Technology formulation /Accessibility to End-users***
		Increased community through integration to other platforms	(+)	Integrate across other architecture	***Build Communities of practice***
		30+ partner base	(+)	Wider partner base	***Build a database of experts - CoP***
		Concerns over data protection on platforms used	(+)/ (-)	Data protection aspects	***Technology formulation/ Technology usages***
		Legitimacy of platform through NDoH dissemination	(+)	Government involvement increased legitimacy	***Core facilitator / XXX***

Table A.8: Self-Renewal MomConnect Event database

Life stage	***Functions***	***MomConnect Key Event and Effect on Ecosystem***	***Effect on Ecosystem***	***Key Ecosystem Activity***	***Attractor Category***
Self-Renewal	**F1-ENT:** Entrepreneurial experimentation	Formation of sub-ecosystems-Nurse Connect, ChildConnect, HealthConnect	(+)	Expand ecosystem focus	***Sub-ecosystems formation***
		Use of learnings from MomConnect to create other ecosystems	(+)	Create repository for main ecosystem	***Project knowledge repository***
	F2-KDev: Knowledge development	Using experienced implementers	(+)	Use experienced actors	***Technology formulation/ Build a database of experts - CoP***
		Research studies on the data from the platform	(+)	Conduct research -on data	***Data analytics/ Project knowledge repository***
		Undertaking surveys and feedback from the platform	(+)	Conduct research-get data	***Data analytics/ Project knowledge repository***
	F3-KDif: Knowledge diffusion	Train brand ambassadors	(+)	Have ecosystem actors as brand ambassadors	***Advertising ecosystem initiative / Accessibility to End-users***
		Research on MomConnect assist with expanding services	(+)	Conduct research-analyse data	***Data analytics/ Project knowledge repository***
		Sharing information amongst ecosystem actors	(+)	CoP to share information	***Project knowledge repository / Build a database of experts - CoP***
		Increase accessibility through local use of languages	(+)	Increase language accessibility to ecosystem	***Open ecosystem***
	F4-GS: Guidance of search	Using experienced implementers e.g. Praekelt	(+)	Use experienced actors	***Technology formulation/ Build a database of experts - CoP***
		International funders	(+)/ (-)	Have internal funding	***Running costs***
	F5-MF: Market formation	Increasing the areas that the platform is utilised	(+)/ (-)	Open up ecosystem	***Open Ecosystem***
	F6-RM: Resource mobilisation	Find actors for implanting sub-ecosystems	(+)	Use expertise form ecosystem	***Open Ecosystem***
	F7-CL: Creation of legitimacy	Formation of sub-ecosystems-Nurse Connect, ChildConnect, HealthConnect	(+)	Expand ecosystems	***Sub-ecosystems formation / Open Ecosystem***

Appendix J: DHIS2 Timeline

A development timeline of the platform based on the technologies, capacity building and implementations is shown in Figure 13.3 where the evolution of DHIS is in three primary parts aligned with time, space and architectures (Braa & Sahay, 2012).

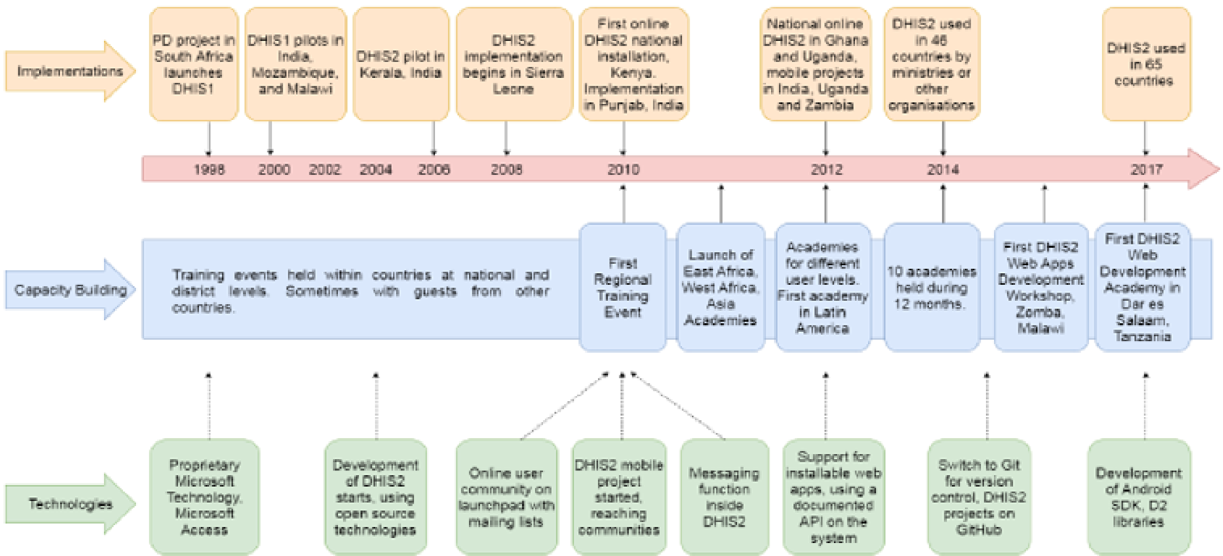


Figure A.2: Timeline in development of DHIS2

Appendix K: DHIS2 Listed Events

Table A.9: Birth Stage DHIS2 Event database

Life stage	*Functions*	*DHIS2 Key Event and Effect on Ecosystem*	*Effect on Ecosystem*	*Key Ecosystem Activity*	***Leverage point***
Birth	**F1-ENT:** Entrepreneurial experimentation	Started from a doctoral project	(+)	Use universities as resource	***Research institutions collaborations***
		Developed on Microsoft Access, VBA, Excel & Windows	(+)	Use readily available technology choices	***Technology formulation***
		Centralised and a standalone application.	(+)/ (-)	Centralised architecture	***Technology formulation***
	F2-KDev: Knowledge development	Started from a doctoral project	(+)	Use universities as resource	***Research institutions collaborations***
		Collaboration between UiO and UCT	(+)	Inter-university collaboration	***Research institutions collaborations/ Strategic alignment***
		Data entry system development on Microsoft proprietary software	(+)	Use readily available technology choices	***Technology formulation***
		DHIS1 pilots launched in India, Mozambique and Malawi	(+)	Test platforms in other countries	***Technology formulation***
		Use of students for in-country deployments	(+)	Action Research as a tool	***Research institutions collaborations***
	F3-KDif: Knowledge diffusion	UiO as core hub of DHIS2	(+)	Use universities as resource	***Core facilitator***
		Data entry system development	(+)	Use readily available technology choices	***Technology formulation/ Accessibility to End Users***
		DHIS1 pilots launched in India, Mozambique and Malawi	(+)	Test platforms in other countries	***Technology formulation***
		Use of students for in-country deployments	(+)/ (-)	Action Research as a tool	***Research institutions collaborations***
	F4-GS: Guidance of search	UiO as core hub of DHIS2	(+)	Use universities as resource	***Core facilitator***
		2004 commencement of development of DHIS2 on open source platform	(+)/ (-)	Look at alternative technologies	***Running Costs/ Technology formulation***
		Start of a strong Master and PhD program	(+)	Action Research as a tool	***Research institutions collaborations***
	F5-MF: Market formation	To alleviate racial discrepancies	(+)/ (-)	Aimed at the public sector	***Accessibility to End Users***
		Expansion through students for in-country deployments	(+)	Action Research as a tool for expanding and informing governments	***Research institutions collaborations***
	F6-RM: Resource mobilisation	Collaboration between UiO and UCT	(+)	Inter-university collaboration	***Research institutions collaborations***
		UiO as core development hub of DHIS2	(+)	Use universities as resource	***Core facilitator***
		DHIS1 pilots launched in India, Mozambique and Malawi	(+)	Test platforms in other countries	***Technology formulation***
		Labour pool from students for in-country deployments	(+)	Action Research as a tool	***Research institutions collaborations***
	F7-CL: Creation of legitimacy	NORAD, PEPFAR, UNICEF, UiO as funders	(+)	Donor funding for ecosystem growth	***Running costs/ Build Global ecosystem***
		UiO as core hub of DHIS2	(+)	Use research groups as resource	***Core facilitator***
		Started from a doctoral project	(+)	Use universities as resource	***Build global ecosystem***
		2004 commencement of development of DHIS2 on open source platform	(+)/ (-)	Look at alternatives	***Running Costs/ Technology formulation***
		To alleviate racial discrepancies	(+)	Aligned ecosystem with government goals	***Strategic alignment***
		Learning program to expand growth of ecosystem	(+)	Action Research as a tool	***Research institutions collaborations/ Open Global ecosystem***

Table A.10: Expansion Stage DHIS2 Event database

Life stage	***Functions***	***DHIS2 Key Event and Effect on Ecosystem***	***Effect on Ecosystem***	***Key Ecosystem Activity***	***Leverage point***
Expansion	**F1-ENT:** Entrepreneurial experimentation	2006-First deployment of DHIS2 in India	(+)	Experimentation with technology	***Technology formulation***
		2010-First online DHIS2 installation in Kenya	(+)	Increase channels for reaching end-users	***Accessibility to End users/ Technology formulations***
	F2-KDev: Knowledge development	Use web based and online Java frameworks	(+)	Utilisation of open source software	***Research institutions collaborations/ Technology formulation***
		Yearly training events	(+)	Produce training material	***Project knowledge repository, Training***
		2010-First online DHIS2 installation in Kenya	(+)	Increase channels for reaching end-users	***Accessibility to End users/ Technology formulations***
		Launch of first regional training event	(+)/ (-)	Expand to more regions	***Training and Learning***

		Messaging function added to DHIS	(+)	Build communication channel	***Accessibility to end users,***
		DHIS2 Mobile started	(+)	Increase channels	***Technology formulation, Accessibility to End users***
		First East Africa, West Africa and Asia academies were launched	(+)	Train more users	***Training and learning***
		More HISP in country nodes for maintenance of DHIS2	(+)/ (-)	Have local implementers	***Build local ecosystem Open Global ecosystem***
	F3-KDif: Knowledge diffusion	First deployment of DHIS2 in India	(+)	Experimentation with technology	***Technology formulation***
		Use web based and online Java frameworks	(+)	Utilisation of open source software	***Technology formulation/ Technology usages***
		Decentralisation of architecture	(+)	Decentralisation of architecture	***Technology formulation***
		Yearly training events	(+)	Produce training material for everyone	***Project knowledge repository***
		In-country training for implementations for end users	(+)	Build capacity in-country	***Build local ecosystem***
		2008-deployment of DHIS2 in Sierra Leone	(+)	Experimentation with technology	***Technology formulation***
		Launch of first regional training event	(+)	Conduct training	***Training and Learning***
		Online user community launched on Launchpad	(+)	Build a knowledge repository and communication channel	***Accessibility to end users, Project knowledge repository***
		DHIS2 Mobile started	(+)/ (-)	Increase channels	***Technology formulation, Accessibility to End users***
		Messaging function added to DHIS	(+)	Build communication channel	***Accessibility to end users,***
		First East Africa, West Africa and Asia academies were launched	(+)/ (-)	Have more channels to train	***Training and learning***
		More HISP in country nodes for maintenance of DHIS2	(+)	Have local implementers	***Build local ecosystem Runniung costs***
	F4-GS: Guidance of search	2010-First online DHIS2 installation in Kenya	(+)	Increase channels for reaching end-users	***Accessibility to End users/ Technology formulations***
		More HISP in country nodes for maintenance of DHIS2	(+)	Have local implementers	***Accessibility to End Users***
	F5-MF: Market formation	Decentralisation of architecture included local developers	(+)	Decentralisation of architecture to include local developers	***Technology formulation/ Build local ecosystem***
		2010-First online DHIS2 installation in Kenya	(+)	Increase channels for reaching end-users	***Accessibility to End users/ Technology formulations***
		DHIS2 Mobile started	(+)	Increase channels	***Technology formulation, Accessibility to End users***
		Messaging function added to DHIS	(+)	Build communication channel	***Accessibility to end users,***
			(+)		
	F6-RM: Resource mobilisation	Decentralisation of architecture included local developers	(+)	Decentralisation of architecture to include local developers	***Running costs/ Build local ecosystem***
		In-country training for implementations for end users	(+)	Build capacity in-country	***Build local ecosystem***
		DHIS2 Mobile started	(+)	Increase channels	***Technology formulation, Accessibility to End users***
		2010-First online DHIS2 installation in Kenya	(+)	Increase channels for reaching end-users	***Accessibility to End users/ Technology formulations***
		Trainings funded by government	(+)	Government covers costs	***Training and learning/ Accessibility to End Users***
		2014-Over 46 countries using technology	(+)	Open to everyone	***Open Global ecosystem, Running costs***
		More HISP in country nodes for maintenance of DHIS2	(+)	Have local implementers	***Build local ecosystem***
	F7-CL: Creation of legitimacy	First deployment of DHIS2 in India	(+)	Experimentation with technology	***Technology formulation/ Core Facilitator***
		Trainings funded by government	(+)	Government covers costs	***Training and learning/ Accesibility to End Users***
		2014-Over 46 countries using technology	(+)	Open to everyone	***Open Global ecosystem, Running costs***
		More HISP in country nodes for maintenance of DHIS2	(+)	Have local implementers	***Accessibility to End Users***

Table A.11: Self-Renewal Stage DHIS2 Event database

Life stage	***Functions***	***DHIS2 Key Event and Effect on Ecosystem***	***Effect on Ecosystem***	***Key Ecosystem Activity***	***Leverage point***
Self-Renewal	**F1-ENT:** Entrepreneurial experimentation	DHIS2 open source makes it accessible to people	(+)	Open up development to enthusiast	***Technology usages Technology formulation***
		Usage of platform for various diseases e.g. TB & Malaria	(+)	Open up development to enthusiast	***Technology formulation***
		Community moved from Launchpad and GitHub to custom made dhis2.org	(+)	Build a community of practice	***Communities of practice Technology formulation***

	F2-KDev: Knowledge development	DHIS2 open source makes it accessible to people	(+)	Open up development to enthusiast	***Technology usages*** ***Technology formulation***
		First web apps development workshop was which was held in Zomba,Malawi	(+)	Open up channels	***Technology formulation,*** ***Accessibility to End Users***
		First DHIS2 web development academy was held in Dar es Salaam, Tanzania.	(+)/ (-)	Open up channels	***Technology formulation,*** ***Accessibility to End Users***
		Community moved from Launchpad and GitHub to custom made dhis2.org	(+)	Build a community of practice	***Communities of practice*** ***Technology formulation*** ***Data analytics***
		Conduct surveys and feedback posts on CoP	(+)	Maintain Communities of Practice	***Communities of practice*** ***Technology formulation*** ***Data analytics***
	F3-KDif: Knowledge diffusion	DHIS2 open source makes it accessible to people	(+)	Open up development to enthusiast	***Technology usages*** ***Technology formulation*** ***Project repository***
		Platform reaches over 60 countries	(+)	Collaboration for development	***Open global ecosystem*** ***Technology formulation***
			(+)		
		First web apps development workshop was which was held in Zomba,Malawi	(+)	Local trainers	***Build local ecosystem*** ***Technology formulation,*** ***Accessibility to End Users***
		First DHIS2 web development academy was held in Dar es Salaam, Tanzania with training	(+)/ (-)	Local trainers	***Build local ecosystem*** ***Technology formulation,*** ***Accessibility to End Users***
		Trainings undertaken by HISP hubs	(+)/ (-)	Local trainers	***Build local ecosystem***
		Community moved from Launchpad and GitHub to custom made dhis2.org	(+)	Use portal as teaching platform	***Project knowledge repository***
		Conduct surveys and feedback posts on CoP	(+)	Maintain Communities of Practice	***Communities of practice*** ***Technology formulation*** ***Data analytics***
	F4-GS: Guidance of search	Conduct surveys and feedback posts on CoP	(+)	Maintain Communities of Practice	***Communities of practice*** ***Technology formulation*** ***Data analytics***
	F5-MF: Market formation	Platform reaches over 60 countries	(+)	Collaboration for development	***Open global ecosystem*** ***Technology formulation***
			(+)		
	F6-RM: Resource mobilisation	Expansion to Android applications		Attract many skills and enthusiasts	***Technology formulation***
		Usage of platform for various diseases e.g. TB & Malaria	(+)	Open up development to enthusiast	***Technology formulation***
		Platform reaches over 60 countries	(+)	Collaboration for development	***Open global ecosystem*** ***Technology formulation***
		Community moved from Launchpad and GitHub to custom made dhis2.org	(+)	Build a community of practice	***Accessibility to end users*** ***Running costs*** ***Project knowledge repository***
	F7-CL: Creation of legitimacy	Expansion to Android applications	(+)/ (-)	Open channels	***Accessibility to End Users.***
		UiO core development team	(+)/(-)	Select the right core intermediary	***Core facilitator***
		Usage of platform for various diseases e.g. TB & Malaria	(+)	Open up development to enthusiast	***Open Global ecosystem***
		Platform reaches over 60 countries	(+)	Collaboration for development	***Open global ecosystem*** ***Technology formulation***
		Community moved from Launchpad and GitHub to custom made dhis2.org	(+)	Build a community of practice	***Accessibility to end users*** ***Running costs*** ***Project knowledge repository***

Appendix L: DHIS2 Literature review for leverage points

Table A.12: DHIS2 Leverage and Event database from publications

Function	Leverage points	DHIS2 Ecosystem Events	Thesis notes
F1-ENT: Entrepreneurial experimentation	Infrastructure Evolution	• Technology arrangements/ Architectural approaches	• Centralisation or decentralisation of architecture • Implementation activities • Conceptualisation of the architecture design • Architectural approaches and tools (Soria, 2014) • Decentralisation – (Manda, 2015) • Bottom up architecting-Fragmentation of HIS (Kossi, 2016) • Perspectives: • An information infrastructure perspective and views health information systems as parts of larger and complex social-technical networks (Nguyen, 2018) • Complexity science as a design, development and implementation guide (Poppe, 2012; Shaw, 2009) • Customisation related challenges and approaches within the context of the public health sector of LMICs (Saugene, 2014) • Architectural insights into how platforms can be designed, governed and used in order to address these issues of heterogeneity in the health sector (Roland, 2018) • how a complex information system like DHIS2 can be implemented in a developing country (Poppe, 2012) • Comparison with other applications e.g Commcare (Chhetri, 2018) • Open generification- building systems for both generic and specific based on principles of openness and collaboration (Gizaw, 2014)
		• Platform development	**<u>Platform integration aspects</u>** • GIS integration – Sierra Leone and India (Øverland, 2010); Ethiopia (Weldu, 2011); • DHIS2 Tracker application for Malaria – Zimbabwe (Matavire, 2016) • DHIS2 Tracker Palestine (Gammersvik, 2015) • Integration of SMS technology (Korvald, 2013) • Spatial analysis (Østeng, 2018) • Feedback via SMS (Sujatmiko, 2015) • Electronic Management Records (Chawani, 2014)
		• Application development	• Tooltips application that advise different aspects – Malawi (Isaksen, 2017) • Offline training app (Bjørge, 2015; Jønsson, 2015) • Webbased mapping (Chitrakar, 2015) • Extract Transform Load Tools (Storset, 2010) • Application for improved collection, recording and use of maternal and child health data (Ngoma, 2014)
		• Interoperability	• Interoperability codes (Manda, 2015; Soria, 2014)
		• Archetypal situations for design-reality gaps	• Developer - sponsor; Global developer -local developer; Local developer and user (Lungo, 2008)
F2-KDev: Knowledge Development	Knowledge repository	• In country module formulation - Capacity building	• MoH initiatives (Johansen, 2012; Siribaddana, 2016)
		• DHIS2 training documentation • Review of relevance of documentation	**<u>Information dissemination:</u>** • Hands-on training and system experimentations techniques(Ngoma, 2014) • Usability of online tools (Aden, 2015; Siribaddana, 2016) • Usability and user documentation (Parmo, 2014)
	Build Local Ecosystem	• Local knowledge - for standardisation and implementation guidelines	• Integration of scientific knowledge and context specific knowledge (Damtew, 2013) • Metis and participatory networks -understand local knowledge (Lewis, 2011)
F3-KDif: Knowledge diffusion/ dissemination	Training *(Capacity building)*	• Training academies	• Global developer -local developer training (Lungo, 2008) • Literacy of users (Macueve, 2008)
	Learning *(Capacity building)*	• Blended learning	• Assessment of blended learning (Aden, 2015) • Aspects to consider for online trainings (Chitrakar, 2015) • Blended learning as a means of cultivating communities of practice (Siribaddana, 2016)

			• Design of e-learning course in areas of poor internet connectivity (Bjørge, 2015; Jønsson, 2015) •
		• Interactive Learning	• Negotiated order of learning (Mengiste, 2009) • Learning from each other and other implementations (Mengiste, 2009) • Different customization sites enabled the emergence of competence-building practices of cross-site interaction, tailored training and collocated learning (Saugene, 2014)
		• Learning programs with universities	• Capacity strengthening Masters and PhD programs (PATH, 2016) •
	Feedback mechanisms	• Participant and User competence assessment	• Challenges in user competence- India (Johansen, 2012)
		• Focus on software developers and engaging feedback	• Transformational feedback using league tables (Frøyen, 2015; Manda, 2015; Moyo, 2016; Sæbø, 2013) • Feedback and feedforward-mobile usage (Shidende, 2015; Sujatmiko, 2015) • Community health workers feedback (Mukherjee, 2017) • Feedback via SMS (Sujatmiko, 2015)
	Evaluation	• Evaluation of current level of implementations, conditions contributing to DHIS2 functionality	• Tanzania DHIS2 review (Klungland, 2011) • Lessons from league tables (Tronerud, 2016; Vasbotten, 2016) • Challenges aligned with shaping FOSS development (Lungo, 2008) • Health workers' practices related to the use of IS tools to support coordination (Shidende, 2015)
	User empowerment	• User empowerment	• Community health workers feedback (Mukherjee, 2017) • Elaborates on ways and means of designing and implementing blended learning programs, which are empowering, informal, participatory and equitable. (Siribaddana, 2016)
F4-GS: Guidance of Search	Technology Transfer	• Development philosophy	• Understand the development philosophy behind e-government initiatives (Macueve, 2008)
		• Guideline development •	**<u>Technology translation</u>**:(Adu-Gyamfi, 2016; Manda, 2015; Nhampossa, 2005; Saugene, 2014) • Build local capacity and expertise • Create learning climate • Maintain and evolve technology over time in a manner of value to the ecosystem
		• Competence Building	• User preferences (Isaksen, 2017) • Strategies (Saugene, 2014; Sheikh, 2015) • Knowledge brokers between health workers and rural areas (Damtew, 2013) • Cultivation of mentors
		• Work practices	• Analysis of Transformation in the work practices (Igira, 2008; Shidende, 2015) • Work practices as part of building sustainability (Landén, 2019) • Duality of work practices traditional versus (Kanjo, 2012)
F5:MF: Market Formation	Partnerships and Collaborations	• Government, University and Industry Collaborations	• Work practices for sustainability (Landén, 2019) • Proactive management activities (Dehnavieh, Haghdoost, Khosravi, *et al.*, 2019) • Trust as a vital component in the orchestration (Hewapathirana, 2018) • Political alliances and negotiations (Lungo, 2008; Mengesha, 2011; Sheikh, 2015) • Limited resource collaborations (Chilundo, 2004) • Reporting systems and tension (Manda, 2015)Sustainability of DHIS2 through actors (Russnes, 2014)
	Communities of Practice	• DHIS2 implementer database management • Portals of information: Launchpad; Github (DHIS2 Community)	• User interaction (Mukherjee, 2017; Wubishet, 2011) • Collaborative online platforms for DHIS2 users and implementers (Staring, 2011)
F6-RM: Resource Mobilisation	Build local ecosystem	• Cultivate local mentors	• Offline training app integrated with mentors (Bjørge, 2015; Jønsson, 2015)
	Core Facilitator	• Decision making	• Decentralisation as a strategy for sustainability (Kimaro, 2006) • Political nature, institutions and power in HIS integration (Sheikh, 2015)
	Focal point of ecosystem	• Implementation for doctors/nurses	• Implementer profile • User profiles (Shidende, 2015) • Blended learning across different professional groups (Siribaddana, 2016)
		• Intervention focus	*<u>e.g Neonatal application, Malaria Tracker, HIV/AIDS applications</u>* • Neonatal Tracker in Malawi (Ismanov, 2018; Ni, 2018) • Malaria tracker (Adu-Gyamfi, 2016; Matavire, 2016) • Information tracker on users (Gammersvik, 2015)
F7-CL Create Legitimacy	Rules	• Governance	• Factors for extensibility and governance of HIS (Adu-Gyamfi, 2016) • Responsibilities (shift from original developers to practitioners) (Mengesha, 2011) • Standardisation as institutional change (Fossum, 2016) • Delegation across the platform (Roland, 2018)
		• Rule-making for boundary spanning	• Rules provide conditions for shaping development and use of e-government applications (Macueve, 2008)

	Standardisation	• Local knowledge - for standardisation and implementation guidelines	• Integration of scientific knowledge and context specific knowledge to create standards (Damtew, 2013)
	Strategy	• Development frameworks	**Implementation frameworks**: • *Two-way boostrapping*-size and scope for locally diverse implementations (Fruijtier, 2019) • *Information infrastructure grafting* - complex and fragile multi-stakeholder ICT implementation processes are conceptualized analogously (Sanner, 2015) • Actor Network Theory (Fruijtier, 2019; Lungo, 2008; Sheikh, 2015), • Institutional theory (Kimaro, 2006) • Conceptual framework to help analyse the relationship between actors, standards and the topic of interest to actors (Abdusamadovich, 2013) • Henri Lefebvre's theory on space (Matavire, 2016) • Amartya Sen's Capability Approach (Mukherjee, 2017) • COP and network of practices for micro processes in OSIS (Mengesha, 2011) • Implementation tension resolution framework (Asangansi, 2014) • integrative framework by Carlile (2004) that includes integration, interoperability and standards • Scaling: understanding of phenomena of scaling, and how this can be utilised to improve the success of HII (Health Information Infrastructures) implementations (Sæbø, 2013)