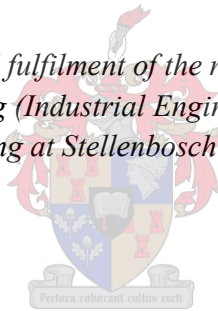


Exploring the Dynamics of Inclusive Innovation Systems through Event History Analysis

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*Thesis presented in partial fulfilment of the requirements for the degree
of Master of Engineering (Industrial Engineering) in the Faculty of
Engineering at Stellenbosch University*



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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated), and that I have not previously, in its entirety or in part, submitted it for obtaining any qualification.

.....April 2022.....

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Abstract

Innovation is commonly viewed as an important factor in stimulating economic growth. Despite the positive effect of innovation, it is often focussed on high-income groups, excluding economically marginalised individuals and groups. This results in a distancing of economic growth from the marginalised groups and leads to inequality. In response, the Innovation for Inclusive Development (I4ID) model has been introduced, which draws on the theory of the conventional Innovation Systems (IS) perspective, to include the marginalised in the process or outcome of innovation. Many I4ID projects have been implemented, but with limited success. In fact, the successful projects are consistently outnumbered by the failed ones, particularly in developing countries. It is argued that reasons for this are the weak understanding of the definition, nature and dynamics of I4ID, among others. This research project addresses the weak understanding, by specifically focussing on enhancing the understanding of the dynamics within I4ID.

The Event History Analysis (EHA) research method is used, together with feedback loops and causal loop diagrams (CLDs) (methods from the System Dynamics domain), to formulate an analytical approach to analyse three successful I4ID projects – identifying the core dynamics consisting of causal relationships between the system functions of innovation that are present within each case. The findings of each case are synthesised to identify five core dynamics across the three cases. Lastly, these five dynamics are combined into one CLD that explains the development of the combined I4ID system, with reference to the system functions.

The findings of each case are synthesised to identify five phases that translate to five core dynamics across the three cases. There are: *Pre-engagement Project Preparation* (First Phase), *Obtain Buy-in from Target Audience* (Second Phase), *Training and First Usage* (Third Phase), *Routine Usage, Feedback and Adjustment* (Fourth Phase) and *Project Disengagement and Handover* (Fifth Phase). Lastly, these five dynamics from the five phases are combined into one final CLD that explains the development of the combined I4ID system, with reference to the system functions.

Opsomming

Innovasie word oor die algemeen beskou as 'n belangrike stimulant van ekonomiese groei. Ten spyte van die positiewe gevolge van innovasie, is dit dikwels gefokus op hoër inkomstegroepe en in die proses word ekonomies gemarginaliseerde individue en gemeenskapsgroepe meestal uitgesluit. Dit veroorsaak dat die ekonomies gemarginaliseerde gemeenskappe nie deel het aan die ekonomiese groei nie, wat lei tot ongelykheid. Om hierdie negatiewe gevolge te oorbrug, is die model van Innovasie vir Inklusiewe Ontwikkeling (IVIO) in die onlangse verlede ontwikkel, wat die teoretiese beginsels en perspektief van die konvensionele Innovasie-Sisteem (IS) gebruik om gemarginaliseerde gemeenskappe te bevoordeel. Hierdeur word gepoog om die gemeenskappe óf te bevoordeel deur die eindproduk van die innovasieproses, óf om die gemeenskappe deel te maak van die innovasieproses. Heelwat IVIO-projekte is as gevolg hiervan geïmplementeer, maar ongelukkig met beperkte sukses - die meerderheid van hierdie projekte is onsuksesvol, veral in ontwikkelende lande. 'n Verskeidenheid faktore is geïdentifiseer wat moontlik die groot aantal onsuksesvolle projekte kan verduidelik, onder andere 'n swak begrip van die definisie, aard en dinamiek van IVIO-projekte. Hierdie navorsingsprojek spreek spesifiek die swak begrip van IVIO-projekte aan, deur te poog om die begrip van die dinamiek in hierdie projekte te verbeter.

Die Historiese Gebeurtenis Analise-navorsingsmetode word saam met terugvoerlusse en kousale lusdiagramme (vanuit die gebied van sisteemdinamika) gebruik om 'n analitiese metode te formuleer wat gebruik word in die analise van drie suksesvolle IVIO-projekte, om sodoende die kern-dinamiek in elk van die drie gevallestudies te identifiseer. Hierdie dinamieke bestaan uit die kousale verhouding tussen die funksies eie aan die IS-perspektief, en word saamgevat om uiteindelik vyf gemeenskaplike kern-dinamieke te identifiseer. Laastens word die vyf kern-dinamieke gekombineer binne een finale kousale lusdiagram, wat die ontwikkeling van die gekombineerde IVIO-sisteem verduidelik binne die konteks van die funksies.

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Glossary

Acronyms and Abbreviations

ARV	Antiretroviral
CCMDD	Chronic Medicine Dispensing and Distribution
CLD	Causal Loop Diagram
DD	Digital Doorway
EHA	Event History Analysis
ERW	Elderly Rural Women
GDP	Gross Domestic Product
GSMA	Groupe Speciale Mobile Association
I4ID	Innovation for Inclusive Development
I4IDS	Innovation for Inclusive Development Systems
ICT	Information Communication and Technology
ICT4D	Information and Communication Technologies for Development
ICT4RED	Information Communication and Technology for Rural Educational Development
IIS	Inclusive Innovation System
IS	Innovation Systems
NARYSEC	National Rural Youth Service Corps
NIS	National Innovation System
PA	Pharmacy Assistant
PHC	Public Healthcare
PPP	Public-Private Partnership
R&D	Research and Development
RIS	Regional Innovation System
SD	System Dynamics
SIS	Sectoral Innovation System
SSP	Stop Stockouts Project
STP	Science and Technology Push
TECH4RED	Technology for Rural Education Development
TIS	Technological Innovation System
TPD	Teacher Professional Development
WHO	World Health Organization

Wi-Fi

Wireless Fidelity

Chapter 1

Introduction

1.1. Background

1.1.1. Innovation and Inequality

Innovation is broadly associated with economic growth. According to Grossman and Helpman (1994), long-term economic growth is driven by industrial innovation and technological development. Romer (1986, 1990) and Stokey (1995) agree that innovation activity is an important factor that influences economic growth. It is recognised that the role of innovation in economic development is key, resulting in broad technological and economic transformations (Altenburg, 2008). In addition, innovation plays an important role in creating new income and employment opportunities (Kraemer-Mbula and Wamae, 2010; Chataway, Hanlin and Kaplinsky, 2014).

Although innovation is usually related to economic growth, in recent times it has been associated with inequality (Grobelaar and van der Merwe, 2016; Apleni and Smuts, 2020). Despite the positive influence of innovation on economic growth and supplementary activities, traditional innovation activities mostly benefit higher-income groups and not groups who are economically and socially marginalised. It therefore means that although innovation activity stimulates economic growth, it does not lead to equitable social development (Simanis, Hart and Duke, 2008). The distinction lies in that conventional innovations often mainly serve to improve the productivity and welfare of middle to high-income citizens (Foster and Heeks, 2013).

Since the global financial crisis in 2008, there has been an increased focus on policy discussion relating to the connection between growth, absolute poverty and inequality, and one of the most notable revelations has been the distancing of economic growth from the incomes of the absolute poor (generally recognised to describe the financial condition of individuals living on less than \$1.25 per day) on a global scale (Schaber, 2011; Chataway, Hanlin and Kaplinsky, 2013). Global wealth is increasingly distributed among a small group of wealthy elites: By 2014, 48% of the global wealth was owned by a minority of 1% of the richest people in the world, and 46.5% of the remaining 52% was owned by the remaining people forming part of the 20% richest people worldwide. This means that the remaining 80% of people worldwide only own 5.5% of the global wealth (Hardoon, 2015). Even though in recent times absolute poverty has decreased, wealth distributions are increasingly

skewed (Piketty, 2014b; Hardoon, 2015). However, innovations aimed toward marginalised communities might be one of the ways to put this right (Maarsingh, Grobbelaar, Uriona-Maldonado and Herselman, 2021).

Multiple innovation approaches have been developed that consider creative solutions with the aim of improving the living conditions of people or people groups who do not benefit from or who do not partake in conventional innovation (Van der Merwe and Grobbelaar, 2018). One of these is the Innovation for Inclusive Development (I4ID) model that has been developed to include the poor in the process and/or outcome of innovation (Foster and Heeks, 2013; Cozzens and Sutz, 2014; Bryden *et al.*, 2017). I4ID is defined by Foster and Heeks (2013) as follows: “The means by which new goods and services are developed for and/or by those who have been excluded from mainstream development; particularly the billions living on the lowest incomes”.

Even though the focus has moved towards including the marginalised in the innovation process, these endeavours are not always successful. Multiple authors (Chianca, 2008; Hussain and Chen, 2018; Singh, Díaz Andrade and Techatassanasoontorn, 2018; Zheng *et al.*, 2018; Heeks and Ospina, 2019) argue that I4ID endeavours or interventions are not “unequivocally effective in improving the lives of community members in developing areas” (Dodson, Sterling and Bennett, 2012), and the failed I4ID initiatives in the developing communities consistently outnumber the successful ones (Krauss, 2009; Dodson, Sterling and Bennett, 2012; Mthoko and Pade-Khene, 2013; Veldsman and Darelle van Greunen, 2015; Mbuyisa and Leonard, 2017).

Chataway, Hanlin and Kaplinsky (2013) highlight one of the reasons by arguing that although I4ID can potentially play an important role in overcoming exclusion, there is generally a weak understanding of the definition, nature and dynamics of I4ID. Murphy (2001) states that “many projects fail not for technological or economic reasons but because the project designers either ignored or oversimplified the social and cultural relationships existing in the implementation context.” In addition, complex socio-cultural contexts of rural communities, often corrupt tribal or government authorities, and persistent and pervasive inequalities present researchers and practitioners with significant challenges (Ramadani, Kurnia and Breidbach, 2018). Especially rural or marginalized communities often view development projects initiated by outsiders with distrust and cynicism, making it difficult to gain entry into a community or sustain buy-in once access has been achieved (Barjis, Kolfschoten and Maritz, 2013; Ramadani, Kurnia and Breidbach, 2018).

1.1.2. Innovation Systems Perspective

The understanding of innovations has in recent times moved towards a system perspective (Rothwell, 1994; Galanakis, 2006) commonly referred to as the Innovation Systems (IS) approach. It is noted that several key processes must be fulfilled in order to build up, grow and mature a system wherein innovations are adopted (Hekkert and Negro, 2009). The idea behind the system perspective is that innovation and technological development are only beneficial and effective if it comprises a problem-solving process which is integrated into a non-linear, interdependent process and disseminated in a complimentary interactive system (Doloreux, 2002). The IS approach is suggested as an adequate approach to provide a holistic and systemic perspective (Biggs, 2001) to analyse systems in which innovations are implemented since it also considers non-technical aspects such as institutions, organizations, economic and organizational features along with the important technical features (Tigabu, Berkhout and van Beukering, 2015a). As such, an innovation system is commonly viewed as comprising structural components (actors, networks, institutions and infrastructure) and the relationships between these components, known as system functions (Bergek *et al.*, 2008; Hekkert and Negro, 2009; Wieczorek *et al.*, 2015), and innovations are ultimately generated by many components and the functions between them (Grobbelaar and Buys, 2006).

The IS approach is beneficial in many regards. It is a central element of technological change (Hekkert *et al.*, 2007), it fosters technology dissemination (Tigabu, Berkhout and van Beukering, 2015a) and it has been used as an analytical tool to explain the success and failures of the generation, implementation and take up of technologies and the role they played in sustainable diffusion (Wieczorek *et al.*, 2015). It also creates an understanding of the weaknesses of the system and provides guidance for the improvement of technology development and diffusion (Wieczorek and Hekkert, 2012). The IS approach has also been incorporated within I4ID to form the Innovation for Inclusive Development Systems (I4IDS) framework that has been used in various instances by many authors (Bazán, Sagasti and Cárdenas, 2014; Ng *et al.*, 2016; Daniels, Ustyuzhantseva and Yao, 2017; Botha, Grobbelaar and Bam, 2019; van der Merwe, Grobbelaar and Bam, 2020) who draw on the theory of the IS perspective and framework, often consisting of system components and functions.

One area of critique that the IS framework has suffered in the past, is the static nature of analyses when it attempted to analyse the diffusion of innovations. The reasoning behind the critique is that though it provides a holistic perspective of the system and the necessary components and functions, it is not comprehensive in its explanation of the dynamic and time-dependent behaviour that leads to

diffusion of innovations and therefore it does not adequately capture mechanisms that work together that leads to change (Bildik, 2014).

One way in which the dynamics of innovation systems can be explained, is by incorporating aspects of System Dynamics (SD) into the IS framework. SD is a modelling and simulation approach that has been widely used to explain complex systems in various domains (Uriona Maldonado *et al.*, 2017). SD enhances the understanding of complex, non-linear systems by providing a holistic picture through mappings of causal mechanisms that influence the system and produce change (Sterman, 2000), known as causal loop diagrams (CLDs). Since the adoption of technological innovations encompass a high degree of complexity (Samara, Georgiadis and Bakouros, 2012), it can be very helpful to better understand the processes and dynamics involved with the implementation and adoption of technologies and other innovations.

Various examples exist of scholars that acknowledge the dynamic nature of innovation systems and incorporated SD methods and/or CLDs along with the IS perspective. Among these are Grobbelaar and Buys (2006), Hekkert *et al.* (2007), Negro (2007), Suurs (2009), Walrave and Raven (2016) and Wicki and Hansen (2017).

Among these authors Negro (2007) and Suurs (2009) have applied a research method known as Event History Analysis (EHA) to analyse and uncover the dynamics of innovations systems by measuring and relating the important aspects (i.e. functions and components in particular) of innovation systems to events (Suurs, 2009) of historical cases of successful innovation projects. Negro (2007) mentions, when the EHA approach is translated to innovations and innovation systems, “it creates insight into the underlying mechanisms that determine technological change through time, more so than other approaches that primarily, and often exclusively, focus on the structure of the system”. This method enables the analyser of innovation systems to “operationalise and measure system functions by relating them to events, and the interaction between system functions can be measured by tracking sequences of events” (Suurs, 2009). Therefore, by applying this approach along with the IS framework, it is possible to uncover dynamics that show how the system develops over time and what contributes to successful projects.

Both Negro (2007) and Suurs (2009) have implemented this approach in the context of renewable technologies. Unfortunately few examples exist of the implementation of this approach within an I4ID context. This research project aims to address this gap.

By drawing on the innovation systems perspective and the methods of EHA, and using CLDs, this project aims to develop an analytical approach that enables the analysis of I4ID project dynamics over time. Additionally, EHA is used to analyse three successful historic I4ID case studies to uncover core dynamics present across the three cases that is used to construct a narrative and map the fulfilment of system functions over time, explaining how an I4IDS typically develops. It is believed that this ultimately results in an increased understanding of I4ID projects that can potentially assist in an improved success rate of I4ID projects in the future.

1.2. Problem Statement

Innovation and technological development have typically been associated with economic growth, but recently it has also been associated with inequality. Despite the positive impact of innovation, it is most often focussed on high-income groups with marginalised individuals failing to benefit from it. As a result, I4ID models have been developed that either include the marginalised in the innovation process or serve their needs. Unfortunately, many of the resulting I4ID projects have a notoriously high failure rate, with successful projects forming the minority. One of the primary reasons for this is the lack of understanding as to what contributes to the success of I4ID projects. An improved understanding regarding the dynamic nature of I4IDS is necessary.

1.3. Research Objectives

The primary aim of this research project is to identify the core dynamics present in I4IDS and construct a narrative to show the development of the dynamics as the system evolves over time by mapping the dynamics between the system functions.

To achieve this aim, the following objectives must be achieved:

1. Identify indicators of system functions to relate case events to the functions they fulfil.
2. Formulate an analytical approach using EHA with the IS and I4IDS perspectives that can be used to analyse I4ID project case studies.
3. Construct a CLD for each case consisting of the core dynamics, demonstrating how the various functions work together during different phases throughout each case to achieve the desired outcomes.
4. Synthesise the results of each case to develop a common narrative between the cases in the form of a CLD showing how the various functions work together during different phases to achieve the desired outcomes.

1.4. Project Scope and Limitations

The scope and limitations of the study are as follows:

1. The three cases that are analysed in this project all take place within South Africa. It is therefore recognised that the outcomes of this project might be typical of a South African context.
2. The nature of EHA is that different case studies are analysed. The analysis of these cases is time consuming and generally only three to five cases would be analysed using this method (Suurs, 2009). EHA does therefore lend itself to generalisation from the outcomes based on arguments obtained from the different cases, but therefore repetition plays an important role to strengthen these arguments.
3. Suurs (2009) points out that, in using EHA, the components as represented by the IS perspective cannot be measured, but each of the events can be related to system components. However, since this research project specifically focus on functions of I4IDS, the components are not specifically tracked, evaluated or analysed.
4. During the consideration of fulfilment of functions throughout this project, only the functions that positively influence others will be used to construct causal chains and CLDs. The added complexity of constructing causal chains and CLDs that negatively influences the fulfilment of other functions falls outside the scope of this project, particularly since the core dynamics typically found in I4ID projects are the focus of this project, and not mechanisms that block or adversely affect I4ID projects.
5. When considering the fulfilment of functions and the resulting causal chains and CLDs, the fulfilment of functions will not be weighted. It is recognised that an event where a meeting is held between two actors does not carry the same weight as an event where the usage of technology within a project becomes embedded in the lives of the marginalised communities, even though both events fulfil the same function. However, the constructed CLDs for each case and the CLD of the synthesised outcome show the core dynamics in relationship form between the functions, i.e. the fulfilment of function 1 results in the fulfilment of function 2, and the added complexity of weighting the fulfilment of functions fall beyond the scope of this project.

1.5. Document Outline

Chapter 1

This chapter introduces the research project by providing background to the problem that this research project aims to address. The problem statement clearly defines the problem, and the research objectives that this project aims to achieve, are stated. The project scope and limitations are also stated.

Chapter 2

This chapter introduces the EHA method that is the research methodology followed during the project. It also introduces system dynamics that is used to construct causal chains and CLDs. Lastly, the research design of this project is provided.

Chapter 3

This chapter focusses on the review of literature of innovation systems and I4ID systems. It also explains the history and evolution of the innovation model to the current systems perspective and introduces the system components and functions of the IS perspective. The chapter also focusses on I4ID systems to obtain an improved understanding of I4IDS to identify (along with the IS framework), what the indicators of functions are to relate case events to the functions.

Chapter 4

This chapter introduces the analytical framework derived from the EHA method to analyse the three cases and to synthesise the findings between them. The six-step approach to do this, is explained.

Chapters 5-7

Within each of these chapters, one of the three cases is analysed according to the analytical framework explained in Chapter 4. Within Chapter 5 the Mafarafara case is analysed, within Chapter 6 the ICT case is analysed and within Chapter 7 the SVS case is analysed. Throughout each chapter, the core dynamics of each case are identified to construct the CLD for the specific case.

Chapter 8

In this chapter, the findings of each case are synthesised to identify similar core dynamics across the cases. These are used to construct the final CLD explaining the common narrative of how the I4IDS develops across the three cases.

Chapter 9

This chapter provides the final conclusions of the research project in accordance with the research objectives set out in Chapter 1. The shortcomings and limitations to the project are discussed and recommendations and future work are given.

1.6. Chapter Summary

This chapter introduces the research project, by providing background to the study in Section 1.1. In Section 1.2, the problem statement is given that stipulates the problem that this project aims to address. The primary aim of the project and the research objectives to achieve this aim is stated in Section 1.3. The limitations and scope of the study is given in Section 1.4 and the outline of this document is provided in Section 1.5.

Chapter 2

Research Methodology

In chapter provides the research methodology that is followed for this research project. The Event History Analysis (EHA) method, that is used to formulate the analytical approach and analyse the case studies in later chapters, is explained in Section 2.1. This is followed by Section 2.2, that explains feedback loops and CLDs, that are the chosen methods to illustrate the dynamics between the different system functions within the three case studies and in the combined dynamic when the findings of the cases are synthesised. Section 2.3 presents the four parts that the project is divided into and explains how the research objectives will be addressed in the different chapters within these four parts.

2.1. Event History Analysis Method

Event History Analysis (EHA) is a research method that has been developed by Van de Ven *et al.* (1999) and Poole *et al.* (2000). This method has been used within the Innovation Systems domain to analyse the dynamics and development of specific innovation systems. EHA in conjunction with the Innovation Systems framework, has been applied by several authors, most notably by Negro (2007) and Suurs (2009).

The EHA method regards development and change processes as sequences of events (Poole *et al.*, 2000; Negro, 2007; Suurs, 2009). Therefore, in the instances where EHA is applied to the analysis of case studies, the foundation of the method is the construction of a narrative, built up by influential sequences of events. A narrative explains how events developed over time, and how certain events led to other events. (Suurs, 2009)

Figure 2-1 illustrates the steps of the EHA method to construct a narrative and these steps are explained in Sections 2.1.1-2.1.6.

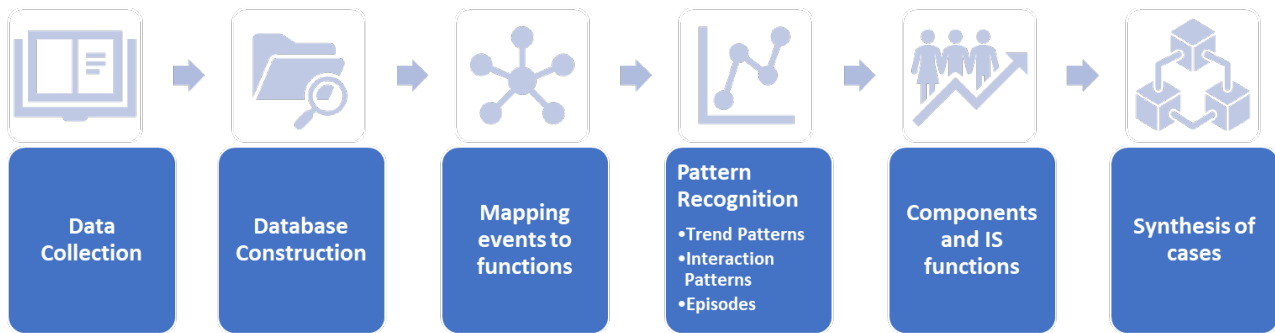


Figure 2-1 Six steps of EHA

2.1.1. Data Collection

A variety of literature sources are consulted to gather sufficient information and data for a case. This include professional journals, newspapers, reports, web sites, etc. Information relevant to the cases being analysed are considered. (Suurs, 2009)

2.1.2. Database Construction

Influential events are identified and sorted in chronological order to make up the database of a case. This is done by reading through literature and identifying and sorting important events. The identification of important events is guided by their fulfilment of the functions of the IS framework. This makes it easier to recognise which activities can be considered as events when analysing the literature. It is important to recognise that in this regard, events are “constructs of the researcher” and in essence they bridge the gap between concrete literature and abstract concepts. (Suurs, 2009)

2.1.3. Mapping events to IS functions

The database contains all the important events, and because they are sorted chronologically, their occurrence in relation to other events are also specified. This allows firstly for relating the events to the system functions and where applicable, the grouping of events in a cluster of events fulfilling a particular function. Important to note is that it can be that one event contributes to more than one function. Also important is that an event can either contribute to a function in a positive manner or in a negative manner. An example of this can be given for the Guidance of Search function, where a positive or negative opinion expressed towards a novel technology encourages its use (positive) or discourages its use (negative). (Suurs, 2009)

2.1.4. Pattern Recognition

Two types of analyses are used based on the work of Abell (1987) and Poole *et al.* (2000), both of are used for pattern recognition in event data. These are (1) Trend patterns, and (2) Interaction patterns. Both methods are used to construct a plot that translates into an insightful narrative that

shows the development of the innovation system. These analyses can both strengthen the outcome of the other, either by confirming the results or the identification of important occurrences. In these instances where one analysis strengthens the other, trend patterns can show particular periods worth considering, and interaction patterns are useful to explain the trends. (Suurs, 2009)

2.1.4.1. Trend patterns

Trend patterns show the fulfilment of individual functions over a period. Quantitative methods can be used to do this, by plotting the aggregated values of particular system functions over time, based on the events. The gradient of the line indicates the presence of events resulting in the fulfilment of the particular function being plotted. This is then a rough indication of the major turning points in the development of the innovation system. For example, if there is a sudden decline or increase in the gradient of one of the functions, it can be seen as a turning point or a shift in events. Should the available data allow for a more concise conclusion, it can be used too. For example, the analysis may show a sudden increase in intensity of a function, which in turn may indicate the participation of specific actors or the introduction of a new technology. (Suurs, 2009)

It is important to note that trend patterns do not have to be based on quantitative analyses. The objective of this method is simply to identify and show key developments. It may be that the qualitative analyses are more suited to a specific case, for example where the content, impact or contribution of events is important and must be interpreted. (Suurs, 2009)

2.1.4.2. Interaction Patterns

If trend patterns are considered to show the result of the development of the innovation system, then interaction patterns present probable explanations of the results. Before this statement is explained, it is important to understand that using events as indicators brings about an important advantage: Events can be linked through “leads-to” relationships that enables the forming of sequences (Abell, 1987; Suurs, 2009). As is stated, “Many events refer to other events; these references can be tracked by checking the content of all the events in the database” (Suurs, 2009). For example, a promise made to support specific activities may result in these activities taking place as a response. (Suurs, 2009)

The overview of event references is used to construct the narrative and the sequence of events are used to construct a storyline. Since the events are used to indicate the system functions, it also provides insight and understanding regarding the role that functions play in the events sequences. Should particular functions occur multiple times in mostly the same sequence, it can be indicative of a cyclic mechanism, called a “motor of innovation” (Suurs, 2009). This makes it possible to identify

and show if there are interactions between the functions. Virtuous or vicious cycles can then be derived if the functions reinforce one another in a positive or negative manner respectively. (Suurs, 2009)

A couple of considerations are also important. Firstly, it is not possible to integrate the whole database of events and divide them all into sequences. The challenge is therefore to identify the events that form part of the motors of innovation. Secondly, it may be that some sequences get split up as a result of one event, leading to different other sequences. Alternatively, it may be that some sequences come together because of one event being the result of multiple others. (Suurs, 2009)

2.1.4.3. Episodes

Based on the outcomes of the fulfilment of the functions, it will be possible to identify certain episodes as the innovation system develops over time: An episode is identifiable by specific fulfilment of functions, patterns thereof or important background information and factors. (Suurs, 2009)

2.1.5. Components and IS functions

It is important to note that in using EHA, the components of the IS perspective are not directly measured. However, not one of the events can exist without the presence of, or that cannot be related to the system components. This means that these components will always be identifiable within the context of the events. In other words, to know which components were at work, an event can be analysed to uncover this. The implication of this is that the event data should contain the required information to recognise the componential drivers or barriers that are in the background of events that result in the motors of innovation. The opposite should also be true, where the effect of the motors of innovation on the system components can also be recognised. (Suurs, 2009)

2.1.6. Synthesis of different cases

Since multiple cases are analysed, each case will uncover its own motors of innovation in the form of causal cycles showing how the fulfilment of one function leads to the fulfilment of others. To achieve the goal of presenting a general insight of the causal cycles present and their developments, the outcomes of each case are synthesised, that in turn strengthens the outcomes by means of replication. (Suurs, 2009)

2.2. Feedback and CLDs

Feedback Loops and CLDs find their place in the System Dynamics (SD) approach (Forrester, 1976). Sterman (2000) defines SD as “a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. SD is also a rigorous modelling method that enables

us to build formal computer simulations of complex systems and use them to design more effective policies and organizations”.

In essence, SD is a transdisciplinary and interdisciplinary approach that improves the understanding of complex systems (Uriona-Maldonado, 2009) and their behaviour by looking at the structures found within these systems and analysing their dynamic behaviour over time using qualitative and quantitative simulation tools. (Lee and von Tunzelmann, 2005; Uriona-Maldonado, 2009; Musango *et al.*, 2012). The system structures show which information influences the behaviour of the systems, enabling the design of robust information feedback structures (Coyle, 1996; Samara, Georgiadis and Bakouros, 2012). SD can be used for any dynamic system within any timeframe and spatial borders (Youssefi, Nahaei and Nematian, 2011). One of the tools typically used in SD is feedback loops (Forrester, 1976).

Feedback illustrates “how actions can reinforce or counteract (balance) each other” (Senge, 2006) and it enables the recognition and learning of recurring system structures. Feedback loops are the primary mechanisms of a dynamic system (Youssefi, Nahaei and Nematian, 2011; Samara, Georgiadis and Bakouros, 2012). Lee and von Tunzelmann (2005) state: “The feedback loop is a path that integrates decision, action, condition, and information, with the path returning to the decision point. This decision controls action, which changes the system conditions, which influence the decision, and so on”. It is also mentioned that systems with greater complexity consist of multiple interconnected feedback loops (Lee and von Tunzelmann, 2005).

To illustrate feedback structures in a system, causal loop diagrams (CLDs) are constructed. The importance of CLDs is twofold: First, during the phase of model development, CLDs graphically illustrate the hypothesised cause-and-effects, and second, they simplify the dynamic model of a system (Ahmadian, 2008). These diagrams illustrate the dynamic behaviour of a system in terms of its components and the relationships found among the components (Sterman, 2000).

When constructing a CLD, feedback is shown by a loop formed by arrows. Arrows illustrate relationships between the variables of the modelled system and the direction of the arrow indicates the direction in which the variables are influenced (Ahmadian, 2008; Youssefi, Nahaei and Nematian, 2011). This relationship can be either positive or negative in nature, usually indicated by positive (+) or negative (-) signs on the upper end of an arrow. When a positive relationship between variables exists, change within one variable results in an influence of the other variable in the same direction. When a negative relationship between variables exists, a change in one variable leads to a change in

the opposite direction of the other variable (Coyle, 1996). An example of this is given in the CLD in Figure 2-2, which illustrates how learning lowers capital costs and stimulates growth.

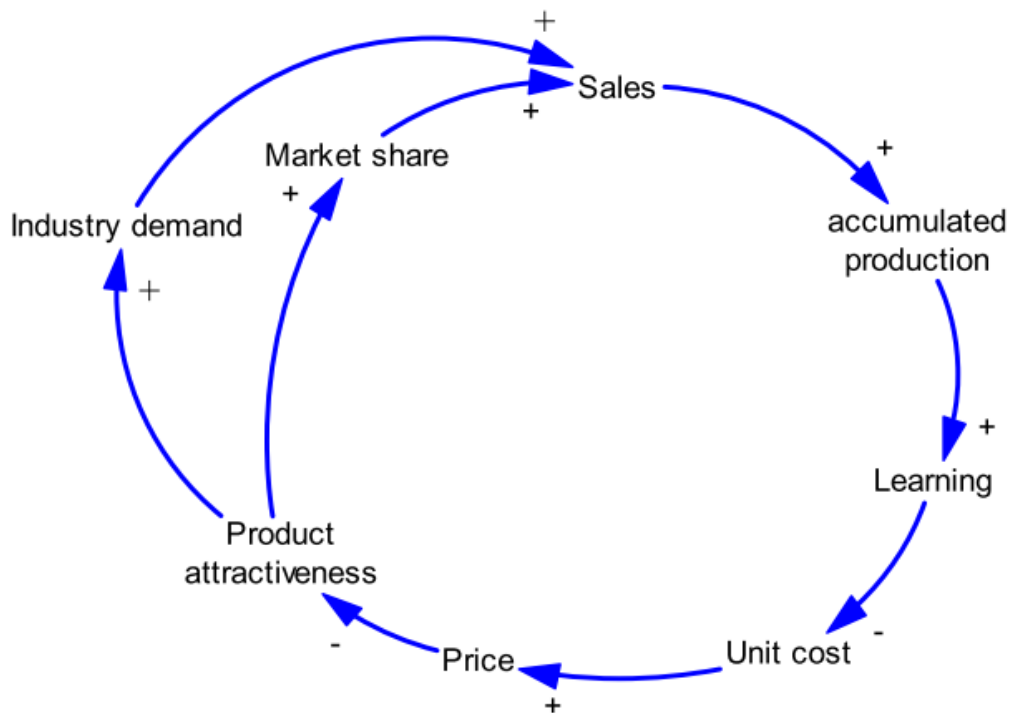


Figure 2-2 Causal loop diagram example (Ahmadian, 2008)

Learning influences *unit cost* in a negative direction, which indicates that as *learning* increases, *unit cost* will decrease. *Unit cost* then influences *price* in the positive direction, which means that as *unit cost* decreases, so would the *price*. A lowered *price* increases *product attractiveness*, which results in an increase in *industry demand* and *market share* which, further promotes an increase in *sales*. Ultimately *sales* stimulate more *learning* by positively influencing *accumulated production*.

Two distinct types of feedback processes exist. These are reinforcing (or amplifying) feedback structures and balancing (or stabilising) feedback structures (Senge, 2006; Samara, Georgiadis and Bakouros, 2012). Reinforcing feedback loops are mechanisms of growth, and thus when things are growing, oftentimes reinforcing feedback structures are at work. It can stimulate accelerated and unwanted decline as well as accelerated and desired growth, where small changes build on itself and amplifies to bigger and increasing changes (Senge, 2006), leading to an exponential effect as time progress. Within a balancing feedback loop, the system exercises goal-seeking behaviour, which means that there is a self-correction mechanism present that attempts to maintain a specific goal or target (Senge, 2006). As such, after a specific disturbance, the system seeks to return to a state of equilibrium (Youssefi, Nahaei and Nematian, 2011; Samara, Georgiadis and Bakouros, 2012).

2.3. Research Design

This research project is divided into four parts to achieve the primary aim of this project as set out in Section 1.3 to uncover the core dynamics present in I4IDS and construct a narrative to show the development of the dynamics as the system evolves over time. These parts are:

1. Problem statement formulation and literature review.
2. Formulation of analytical approach to analyse I4IDS dynamics
3. Case study analysis
4. Synthesis

The way the chapters in this document address the four parts and the research objectives to achieve the primary aim of this project is indicated in Figure 2-3 and explained in Sections 2.3.1-2.3.4.

2.3.1. Problem Statement Formulation and Literature Review

Before being able to develop an analytical approach to analyse three case studies, two important steps are necessary. First, it is required to clearly define the problem and in doing so, formulate the primary aim and objectives of this research project. This is done in Chapter 1. Second, it is required to conduct a thorough literature review to gain an understanding of the concept of innovation and its role among the marginalised, the latest model of innovation (i.e., the IS perspective) and how the IS perspective views innovation, what are the components and functions of the IS perspective and how can the IS perspective be adapted to adhere to inclusive innovation in the form of the I4IDS perspective. Because this research project specifically aims to uncover core dynamics within I4IDS, it is of particular importance to identify indicators of the system functions within the IS perspective and the additional indicators that the I4IDS perspective brings about. This is done in Chapter 3.

2.3.2. Formulation of analytical approach to analyse I4IDS dynamics

A five-step analytical approach is formulated in Chapter 4 that is based on the six steps of the EHA research method discussed in Section 2.1. The indicators of system functions that are identified in Chapter 3 are used to inform the third step of the analytical approach that relates the events of cases to the functions they fulfil.

2.3.3. Case Study Analysis

The analytical approach formulated in Chapter 4 is applied to three cases where I4ID projects were implemented within marginalised communities. For each case study, the events that occur during the case are identified and sorted chronologically. The events are related to the system functions that they fulfil and this is used to divide each case into different episodes (known as phases) based on the different objectives, desired outcomes and activities that typically take place during different times

in the case. Within each phase, patterns of functional fulfilment are identified, known as interaction patterns, where the fulfilment of one function would result in the fulfilment of other functions. These patterns are used to identify feedback loops that are used to construct a CLD for each case that illustrates the narrative story, showing how the different functions work together and influence one another throughout each case.

2.3.4. Synthesis

The outcomes of the analyses of the case studies in Chapter 5, Chapter 6 and Chapter 7 are synthesised in Chapter 8 to develop a narrative story in the form of a CLD, explaining the development of core dynamics within I4IDS as the system evolves over time.

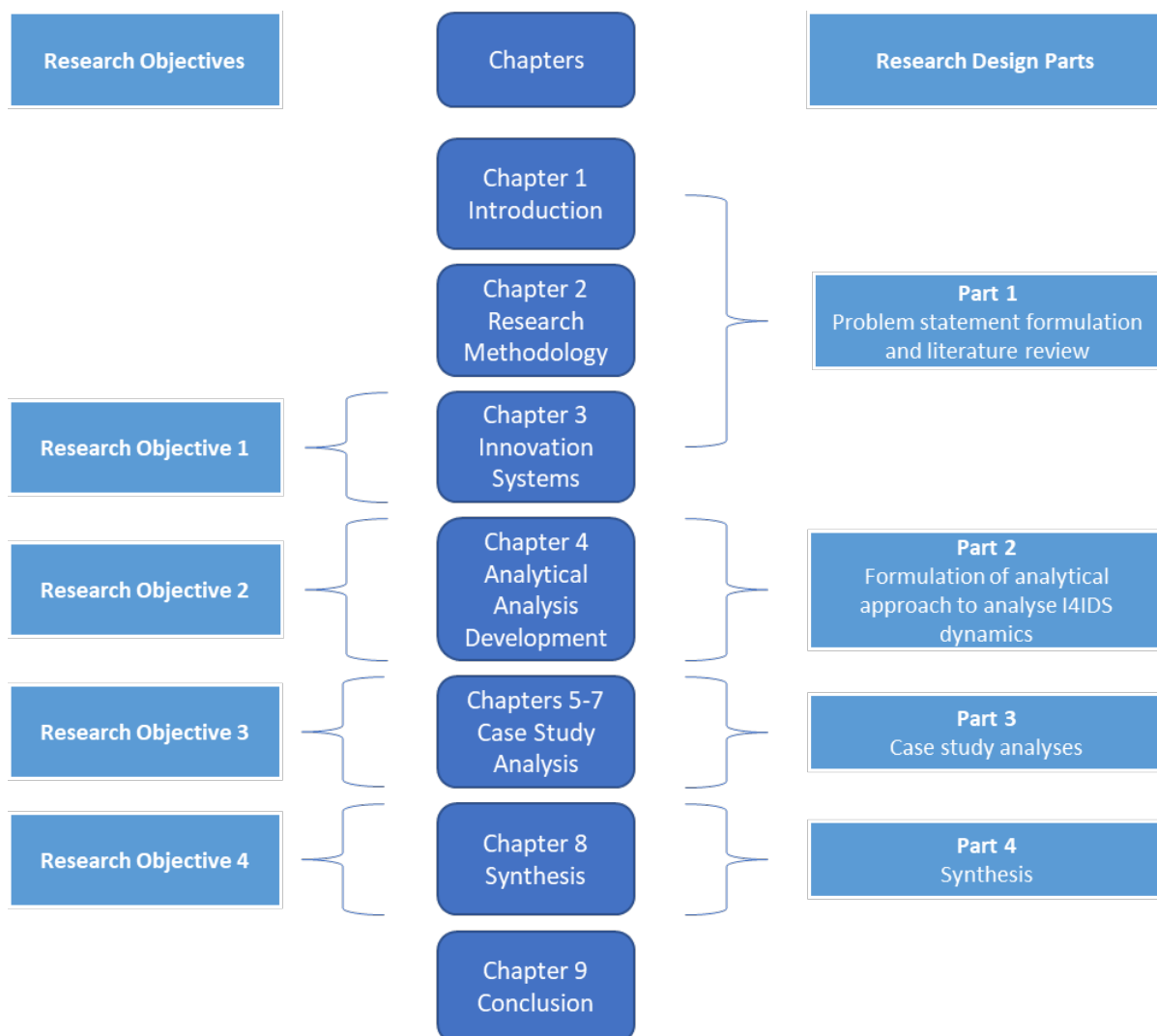


Figure 2-3 Research Design

2.4. Chapter Summary

Within this chapter, the research methodology of the research project is given. In Section 2.1, the EHA research method is explained that guides this research project and forms the basis of the analytical approach that is used to analyse the case studies. This is followed by explaining feedback loops and CLDs that are used to construct the narratives of the core dynamics and the development of functions during the analysis steps in the project in Section 2.2. Lastly, in Section 2.3, the research design of this project is given that sets out the steps to achieve the primary aim and research objectives of the project.

Chapter 3

Innovation Systems

In this chapter, innovation systems literature is reviewed and discussed, with specific reference to innovation for inclusive development systems (I4IDS). The chapter starts by introducing the general concept of innovation (see Section 3.1) and touches briefly on the general role of innovation among marginalised groups in Section 3.2. This role, specifically the relevance I4IDS on these people groups, is discussed in more detail in Section 3.5 during the review of I4IDS. However, to better understand the dynamics of innovation systems and what contributes to the success of I4IDS specifically, it is necessary to study the evolution of the innovation process model to the current model of the systems view of innovation, referred to as the innovation systems (IS) framework. This will be discussed as background in Section 3.3. The components and functions of innovation systems, discussed in Section, 3.4, will also shed more light on what follows in Section 3.5.

3.1. The Concept of Innovation

According to Edquist and Hommen (1999), an innovation can be defined as the process of transforming new or already-known knowledge in such a way that it adds value for individuals or people groups. The innovation process results in the development of products and/or services through a combination of technical, social and economic processes (Johnson, 1992; Edquist and Hommen, 1999; Kraemer-Mbula and Wamae, 2010).

It is stated that various definitions of innovation can be found in literature (Sonne, 2012). However, a comprehensive explanation of innovation is presented by Joseph Schumpeter (1934) that is still appropriate today (Van der Merwe, 2018). Schumpeter explains that five types of innovations exist, which are the following:

- Innovation in the form of developing a new product or adapting an existing product;
- Innovation in the form of a new process within an industry;
- Innovation in the form of the formation of a new market;
- Innovation in the form of emerging sources to supply raw materials and other necessities; and
- Innovation in the form of adapting industrial organisations (OECD, 1997).

A more recent definition of innovation is provided by Oslo Manual: Innovation is “the implementation of a new or significantly improved product (goods or services), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations” (OECD/Eurostat, 2005).

3.2. The Role of Innovation among the Marginalised

Recent research acknowledges the importance of innovation in stimulating growth, since innovation offers considerable potential to acquire developmental effects (Kraemer-Mbula and Wamae, 2010). Through innovations ample opportunities are provided to address pressing issues such as poverty and inequality (Van der Merwe, 2018). In fact, enough evidence exists that support the notion that innovations play a key role in alleviating extreme poverty (Ver Loren van Themaat *et al.*, 2013). As a result, many organisations are using different innovation models in an effort to address the needs of marginalised groups (Van der Merwe, 2018). Unfortunately, despite these efforts, inequalities are increasing (Kraemer-Mbula and Wamae, 2010). Foster and Heeks (2013) state that though the view that innovative activities alleviate mass poverty may be true, the opposite is also true, with innovation being a key driver of inequality and exclusion in developing countries. To better understand the dynamics of innovations and what constitutes to its success, it is necessary to study the evolution of the innovation model.

3.3. Innovation Systems Background

Constant market changes and new technological developments have led to various changes and adaptations of the innovation process model since its first inception in the late 1950's and mid 1960's. At present five generations of innovation models can be identified in literature (Rothwell, 1994; van der Merwe, 2018).

3.3.1. Linear Model of Innovation

The first developed model was a result of technological push as a rise in technological development led to a rapid bloom of new industries and regeneration of existing industries in the 1950's. Under this model, focus was firmly on research and development (R&D) and manufacturing which led to new technologies being developed. This led to the innovation model perceived as a basic linear process as illustrated in Figure 3-1. Unfortunately, very little focus was on the transformation of R&D to manufactured products or to the part that the marketplace play in the whole process. (Rothwell, 1994)

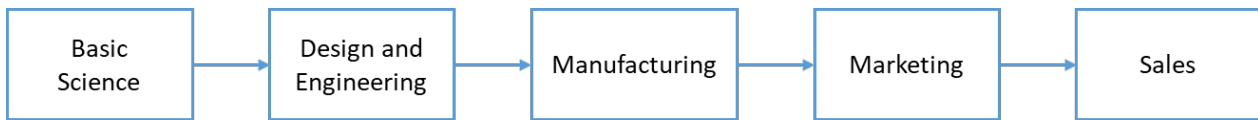


Figure 3-1: First generation innovation model [(Rothwell, 1994)]

The second-generation innovation model was developed as a result of a change of focus within the competitive markets in the latter half of the 1960's. Investors' focus shifted to "rationalization technological change", rather than on the development of new products. Along with the shift in focus, leading companies placed strategic emphasis on marketing to gain prominent market share and focussed prominently on the "demand-side factors". This model represents the idea that the market was the main source for ideas that determines the direction of R&D. The model is illustrated in Figure 3-2. Users of this model ran the risk of neglecting long-term R&D programmes as they get caught up in seeking incremental improvements of technologies to meet user needs, thus prohibiting flexibility to adapt to radical market changes. (Rothwell, 1994)

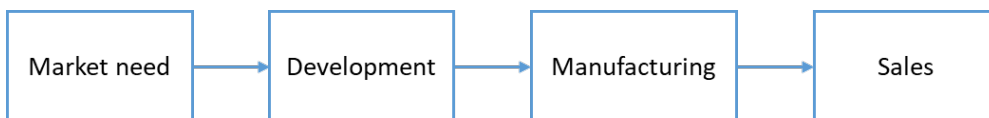


Figure 3-2: Second generation innovation model [(Rothwell, 1994)]

3.3.2. Coupling Model of Innovation

The first and second model faced critique for being linear models that ignore feedback loops and iterative learning (Godin, 2006; van der Merwe, 2018). This contributed to further development of the model of the innovation process, resulting in the third-generation model for innovation, called the "Coupling Model", shown in Figure 3-3. Other factors further contributed to its development: Due to an increase of economic pressures in the 1970's, resultant from two oil crises, meant that inflation rates increased and demand rates slowed. For about a decade, a new focus on cost control and reduction ensued. It became important to understand what was necessary for a successful innovation in order to reduce wasteful failures, and thus increased research on the topic followed. The research revealed that the success of an innovation was not dependent on one or two factors, but rather multiple factors working well together, and thus a push-pull model was necessary (Galanakis, 2006). This highlighted the importance of features such as feedback loops. (Rothwell, 1994)

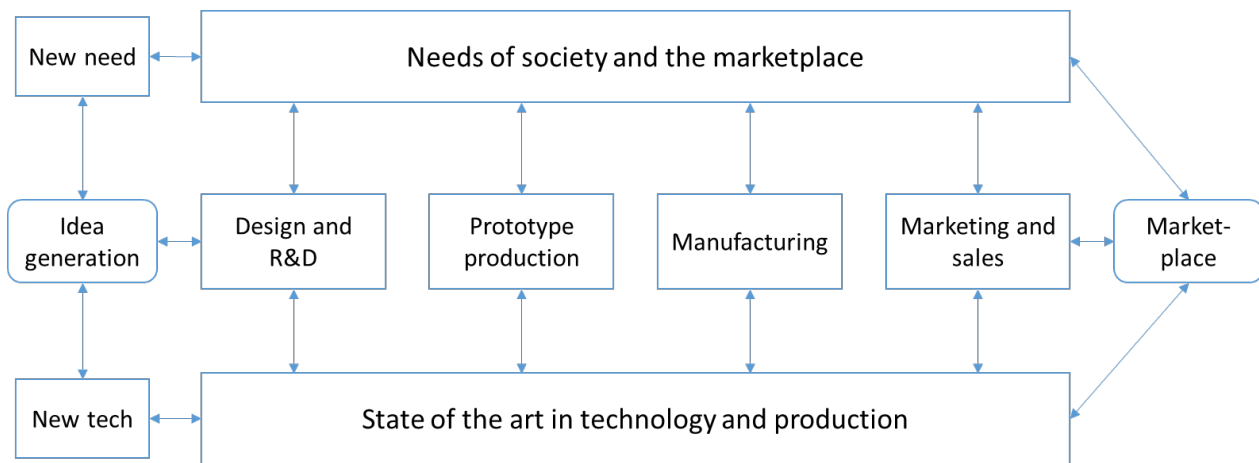


Figure 3-3: Coupling model of innovation [(Rothwell, 1994)]

3.3.3. Fourth Generation Innovation Model

During the 1980's, economic pressures started to lessen and companies could focus on core businesses and technologies. Companies started to see the benefits of strategic alliances with one another, which the government both encouraged and supported, leading to even small companies starting to engage in external networking activity. The two most important factors that influenced the perspective of an innovation process during this time, was “integration” and “parallel development” (Rothwell, 1994). This meant that companies would “integrate suppliers into the new product development process at an early stage while at the same time integrating the activities of the different in-house departments involved, to work on the project simultaneously (in parallel) rather than sequentially” (Rothwell, 1994). This meant that innovation was viewed as a parallel process, rather than sequential, as was represented by the previous three models. The result was that the key feature of this approach was “functional integration” when a project was undertaken, so that the expertise of each specialist would be considered (Galanakis, 2006).

3.3.4. Systems View of Innovation

The latest model of innovation has shifted towards a “system of innovation” theory known as the Innovation System (IS) approach (Rothwell, 1994; Galanakis, 2006). This theory “relates the policy of innovation players to the ability of firms to be innovative” (Galanakis, 2006), which then influences the wealth of a country (Edquist, 1997; Sundbo, 1998; Galanakis, 2006). Furthermore, the theory argues that certain social and economic factors, along with specific actors within the system, affect the creation of innovation within or across national borders (Galanakis, 2006).

The systemic approach of innovation is established in the idea that innovations are ultimately generated by many components and the relationships between them (Grobelaar and Buys, 2006). Therefore, the innovation process cannot be divided into isolated and strictly sequential phases

(Samara, Georgiadis and Bakouros, 2012). An important component of an innovation system is the interlinked institutions and connections that generate, diffuse and adapt technical and scientific knowledge (Edquist and Johnson, 1997; Rodriguez and Lenin Navarro Chavez, 2011). It is important to note that some authors use the term “institution” inconsistently, referring to institutions both as regulatory policies and as organizations (Grobbelaar and Buys, 2006). As Johnson (1992) states, institutions in the IS perspective refers to “the set of habits, routines, rules, regulations and governing relations” that impact and form social interactions (Johnson, 1992). Innovation systems also comprises of multiple actors that are relationally linked to one another through flows of technological, financial and human resources, implicit knowledge and “regulatory and trade relations” among others (Niosi, 2002). The relationships among actors may be between governments, private organizations, universities, companies, and public agencies (Niosi, 2002). Such a system of innovation can be found on various scales and levels: industrial, local, regional, national or international (Rodriguez and Lenin Navarro Chavez, 2011). This perspective of innovation systems relays the idea that the innovation process is caused by a “complex set of relationships” between actors who are responsible for producing, diffusing and distributing different types of knowledge (Samara, Georgiadis and Bakouros, 2012).

Although the system perspective seemingly encourages collective action, the primary purpose of this perspective is that of an analytical tool to improve illustration and understanding of the dynamics of the system and the characteristics that define the innovation system (Bergek *et al.*, 2008; Rodriguez and Lenin Navarro Chavez, 2011). The IS approach then enables the identification of important components in the system that contribute to the fulfilment of the system’s functions (Grobbelaar and Buys, 2006). It helps to “describe the institutions and links between actors involved in the process of innovation” (Rodriguez and Lenin Navarro Chavez, 2011). Furthermore, it provides a way to analyse the behaviour of the actors engaged within the system, looking at their “strategic direction and underlying mechanisms” that motivate their individual actions and engagement with other actors found in the system (Rodriguez and Lenin Navarro Chavez, 2011).

The IS approach has been used by various authorities; from regional and national agencies to international organizations resulting in four different IS concepts found in literature: National System of Innovation/National Innovation System (NIS) and a Regional Innovation System (RIS) when “a geo space is a unit of analysis” (Wieczorek and Hekkert, 2012), a Sectoral System of Innovation and Production/Sectoral Innovation System (SIS) that is not limited to national borders (Wieczorek and Hekkert, 2012) and a Technological Innovation System (TIS) that is also not limited to national borders, “but are more specific in scope than a SIS” specifically involving the developing, diffusion

and use of technology (Carlsson and Stankiewicz, 1991; Bergek *et al.*, 2008; Wiczorek and Hekkert, 2012).

These different IS concepts are characterised by the specific setting for which they are used. For example, an innovation system can be seen as a NIS if it is “bounded by a nation-state”, or a SIS when it portrays a specific economic sector, or a TIS when a specific technology is the bounding mechanism between an actor-network and institutions. (Tigabu, Berkhout and van Beukering, 2015a)

3.3.4.1. National Innovation System

The NIS framework suggests that a “nation” is an appropriate boundary for an innovation system. The reason for this is twofold. Firstly, there exist various differences among countries with regards to the investment in R&D activities, the activities themselves and the institutional set-up of a specific country. Secondly, the policies aimed at guiding and governing the innovation system or economy as a whole are developed and implemented at national level. (Lee and von Tunzelmann, 2005)

Literature on NIS has branched into two views with different central foci (Godin, 2007). The first branch focusses mainly on analysing institutions and policy rules (Nelson, 1993). The second view is more “conceptual”, and it focusses primarily on knowledge “and the process of learning itself” through “learning-by-doing” and “learning-by-using” (Lundvall, 1992).

The NIS framework was first introduced by Freeman (1987) as he sought to explain and interpret Japan’s economic success post-World War II (Grobbelaar and Buys, 2006). He defined the NIS as “the network of institutions of private and public sectors, whose activities and interactions initiate, import, modify, and diffuse new technologies” (Freeman, 1987).

As the concept progressed, the two different branches with differing central foci appeared and led to scholars defining a NIS somewhat differently than what Freeman originally did. According to Lundvall, the NSI is defined as “the elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge...and are either located within or rooted inside the borders of a nation state” (Lundvall, 1992). Nelson (1993) has a simpler definition as he defines it as “a set of institutions whose interactions determine the innovative performance...of national firms” (Nelson, 1993).

According to Freeman (1987), the main idea of the NIS framework is that the rate of technological change within a country and the success of the country’s firms with regards to goods and service

provision in international trade, are not solely dependent on the amount of technological and R&D activities. Rather the manner in which available resources are used at firm and national level, are also important factors and strongly influential. (Walsh and Le Roux, 2004)

This view is supported by Lee and von Tunzelmann (2005) as they state that two active sub-systems exist: The “technological system” responsible for “producing the technological outputs required for production to be carried out” and the “industrial system” responsible for “the translation of those technologies into product outputs” (Lee and von Tunzelmann, 2005).

With regards to its physical composition, a NIS consists of interlinked actors such as universities and other forms of academia, industries and governments that cooperate to produce and diffuse innovation in the form of knowledge. The universities and industries are the research producers that are responsible for R&D activities, whereas governments are responsible for the formulation of institutions. Together these actors create a national environment in which innovations can be produced, governments can be formed and policies be implemented that impacts the innovation process. (Chung, 2002; Guan and Chen, 2012)

In the context where the term “innovation” exclusively refers to technological innovation, Chung (2002) defines a NIS as follows: “We... define a NIS as a complex of innovation actors and institutions that are directly related to the generation, diffusion, and appropriation of technological innovation and also the interrelationship between innovation actors”. The focal point here is to formulate a national setting that successfully incorporates innovation actors and stimulate information flows among them that ultimately results in the generation of innovations. (Chung, 2002)

Lastly, the NIS framework suggests that different countries have more or less the same actors (i.e. universities, public and private research firms and private R&D firms etc.) that are responsible for the development of innovations. However, there exist big differences between different countries with regards to the interaction among the actors to achieve this aim (Lee and von Tunzelmann, 2005).

3.3.4.2. Regional Innovation Systems

RSI originated from the NSI perspective and is therefore very similar. In fact, certain scholars make no distinction between the two perspectives and simply view a RIS as a subset of a NIS (Doloreux, 2002). Cooke, Uranga and Etxebarria (1998) define a RIS as “a system in which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness”.

The RIS perspective supports the notion that innovations cannot be exclusively produced by firms. Instead, innovation is seen as a process, dependent on multiple factors that are “internal and external to firms” (Doloreux, 2002). The main components of a RIS are then firms, institutions, knowledge infrastructure and innovative policy (Doloreux, 2002).

Firms are primarily responsible for producing and diffusing knowledge. Firms that are grouped within the same environment, interact with one another. Furthermore, their responsibilities stretch further by playing an important role in creating and developing technologies and influencing their uptake and utilization. (Doloreux, 2002)

Institutions are responsible for various important processes in the system. They regulate the use of knowledge, provide direction by addressing uncertainties, and give incentives (Jacobsson and Carlsson, 1997). Institutions can either refer to formal structures with an “explicit purpose” or to more informal structures such as “norms, rules and laws that influence innovation” (Doloreux, 2002).

Knowledge infrastructure refers to the “physical and organizational infrastructure needed to support innovation” (Doloreux, 2002). Policy-oriented regional innovation refers to innovation where policies are established to “to support regions’ endogenous potential” that allow technologies to be decimated on regional level (Doloreux, 2002).

3.3.4.3. Technological Innovations Systems

Carlsson and Stankiewicz (1991) define a TIS as “a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilisation of technology”. Bergeck *et al.* (2008) support this definition and describe a TIS as “socio-technical systems focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or both)” (Bergeck *et al.*, 2008).

The implication is that a TIS does not only include components specifically related to the technology in focus, but encompasses all components that have an effect on the innovation process of the specific technology (Bergeck *et al.*, 2008). Technological innovations have become complexed and major risks are involved to the extent that an individual system actor working alone cannot produce and exploit it successfully (Chung, 2002). This where the systems approach and the TIS framework are very helpful (Chung, 2002).

Actors, networks, institutions and technology make up the structural components of a TIS (Edquist, 1997). Actors refer to public or private and governmental or non-governmental organizations that are responsible or part of the development, diffusion and uptake of a specific technology. Networks are “communication channels” that facilitate information and knowledge flow between the actors present in the system. Institutions refer to the formal or informal policies that guide actors’ decision making and actions among one another. (Tigabu, Berkhout and van Beukering, 2015a)

At its core, the primary function of the TIS framework is the analysis of the underlying structure of the innovation system (referring to the actors, institutions, networks and technology) and the fundamental activities that contribute to the forming and growth of the technological field. (Hekkert *et al.*, 2007; Bergek *et al.*, 2008; Wieczorek *et al.*, 2015)

In particular, a TIS plays an important part in the uptake of new technology among actors, by seeking to fulfil crucial and often fundamental activities that negate the challenges encountered by new technologies entering the technological field, such as lack of legitimacy or awareness and high costs. These activities of a TIS are referred to as “system functions” and it guides the actions of actors, usage of resources and the formation of market space to protect it from competition and other influencing factors (Tigabu, Berkhout and van Beukering, 2015a).

A TIS is distinguished from other IS frameworks by the primary focus being on the analysis of an up-and-coming technological field. Yet in a TIS, organizations are globally involved to source and gain important knowledge that contribute to successful development and uptake of technologies. (Wieczorek *et al.*, 2015).

3.3.4.4. Sectoral Innovation Systems

Malerba (2002) defines a sectoral system of innovation and production (i.e. SIS) as “a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products”. SIS revolves around a “knowledge base, technologies, input and demand” (Malerba, 2002). Actors refer to individuals or organizations that are at different aggregate levels with different skills, goals, knowledge and structures. These can include firms (consumers, manufacturers, suppliers, etc.) or non-firm organizations (academia, financial organizations, governments, etc.). They are connected through various communication channels, co-operating opportunities and other processes that are ultimately formed and guided by institutions. (Malerba, 2002)

Therefore, the prominent and structural components of a SIS are products, actors, knowledge and learning processes, and institutions. Other components include “Inputs and demands, and the related links and complementarities”; “Mechanisms of interactions both within firms and outside firms” and “Processes of competition and selection” (Malerba, 2002).

3.4. Components and Functions of IS

The IS perspective views an innovation system as comprising of (1) structural components, and (2) the relationships between them, called functions of an innovation system (Lundvall, 1992; Freeman, 1995; Suurs, 2009).

3.4.1. Structural components of IS

Initially Carlsson and Stankiewicz (1991) stated that the components of an innovation system are actors, interactions and institutions. However, some studies showed that missing infrastructure within a system can be the cause of failure for these systems (Wieczorek and Hekkert, 2012). Many authors, including Foster and Heeks (2013), Freeman (1995) and Suurs (2009) therefore conclude that the four structural components used throughout literature are:

- Actors;
- Networks;
- Soft and hard institutions; and
- Infrastructure.

3.4.1.1. Actors

Actors refer to the components of innovation systems that produce innovation activities and are mostly individuals and organizations (Wieczorek and Hekkert, 2012; van der Merwe, 2018). Actors can be identified as the components that play a role in the innovation process or economic activity (Wieczorek and Hekkert, 2012). Typically, actors are “civil society, government, non-governmental organisations (NGOs), companies (start-ups, small and medium-sized enterprises [SMEs], multinationals, large firms), knowledge establishments (universities, technology institutes, research centres, schools), and other parties (legal organisations, financial organisations/banks, intermediaries, knowledge brokers, consultants)” (Wieczorek and Hekkert, 2012).

3.4.1.2. Interactions/Networks

A network describes relationships and links amongst actors, institutions and innovations (Suurs, 2009; Wieczorek and Hekkert, 2012). Linkages form amongst actors, institutions and innovations and when a configuration is formed among these components, it is called a network. Networks grow to become a fundamental part of the innovation system, since it is the main channel for knowledge

development and diffusion. The dynamics of an innovation system are the result of structural tension and synergies among actors, institutions and innovations that are represented by networks and relationships among them. (Suurs, 2009)

3.4.1.3. Institutions

Institutions refer to sets of habits, routines and concepts (soft institutions) common to humans that are shaped by rules, norms and strategies (hard institutions) (Wieczorek and Hekkert, 2012). Institutions play an important role to reduce uncertainties, guide the use of knowledge, settle conflicts and stimulate incentives for development of innovation. Institutions can either be formal structures with a narrowly defined purpose or informal structures that influence norms and laws of the game. (Edquist, 1997).

The alignment of institutions in an innovation system is crucial and it does not automatically take place (Jacobsson and Lauber, 2006). It has a direct impact on the presence and performance of actors and is therefore very important (Suurs, 2009).

3.4.1.4. Infrastructure

Within literature, three types of infrastructure are found. These are physical infrastructure, knowledge infrastructure and financial infrastructure. Physical infrastructure refers to tangible infrastructure, such as buildings, roads, bridges, ports for transportation on sea and air, telecommunication networks, tools and artefacts among others. Knowledge infrastructure refers to any form of knowledge, expertise and information. Financial infrastructure encompasses all forms of financial support which are typically generated through subsidies, financial programs and grants. (Wieczorek and Hekkert, 2012)

3.4.2. Functions of IS

Functions are first mentioned in TIS literature and it describes the processes that are important for well performing innovation systems and gives a good perspective of the dynamics of an innovation and how well the system is functioning (Hekkert *et al.*, 2007; Bergek *et al.*, 2008; Wieczorek and Hekkert, 2012). Instead of focussing on the static structures, it places an emphasis on how key processes change over time (Quitow, 2015). In essence, the functions reveal the state of an innovation system at any specific moment in time (Wieczorek and Hekkert, 2012).

When analysing the dynamics within an innovation system, it is obvious that many activities are taking place. To map all these activities is simply not feasible. As a result, the relevant activities must

be identified. These refer to activities that directly influence the goal of an innovation system, which is the generation and diffusion of innovations. (Hekkert *et al.*, 2007)

Within literature, seven functions are identified (Johnson, 2001; Hekkert *et al.*, 2007; Bergek *et al.*, 2008; Wieczorek and Hekkert, 2012). These are:

- Entrepreneurial Activities;
- Knowledge Development;
- Knowledge Diffusion;
- Market Formation;
- Guidance of Search;
- Creation of Legitimacy; and
- Resource Mobilisation.

3.4.2.1. F1: Entrepreneurial activity

This function involves commercial and entrepreneurial activities that are linked to a novel innovation (Hekkert *et al.*, 2007). An innovation system cannot function without entrepreneurs and entrepreneurial activities (Kim, Ro and Florida, 2009). Therefore, entrepreneurship is seen as an important function where business opportunities are sought for and exploited. Within the context of the IS framework, entrepreneurs fulfil the role of exploring the potential for new knowledge generation, networks and markets, technologies and applications in such a way that it transcends into concrete actions that takes advantage of business prospects (Hekkert, Harmsen and de Jong, 2007; Wieczorek *et al.*, 2015). Indicators of entrepreneurial activities include entry of firms or other actors within the innovation system, portfolio expansions to diversify business strategy (Hekkert *et al.*, 2007), manufacturing and/or installing technology (Tigabu, Berkhout and van Beukering, 2015b) and starting innovation projects (often with commercial aims) among others (Long, Blok and Coninx, 2019).

3.4.2.2. F2: Knowledge development

This function represents all activities that are responsible for the generation of knowledge (Wieczorek *et al.*, 2015). As Lundvall (1992) states “the most fundamental resource in modern economy is knowledge and, accordingly, the most important process is learning”. Accordingly, learning mechanisms are fundamental to innovation processes, and therefore R&D and knowledge generation are necessities for the innovation system (Hekkert, Harmsen and de Jong, 2007). This function includes “experienced-based knowledge development through doing, using and interacting” (Wieczorek *et al.*, 2015). Indicators of knowledge development activities within an innovation system

include academic research and studies (Bergek *et al.*, 2008), market surveys, pilot projects (van der Hilst, 2012), feasibility studies, developing promotional materials, developing prototypes, development of models, testing performance of models, and adapting models (Tigabu, Berkhout and van Beukering, 2015b) and learning activities, particularly learning-by-doing (Hekkert *et al.*, 2007).

3.4.2.3. F3: Knowledge diffusion

This function encompasses all channels and networks that share generated knowledge among actors within the system (Hekkert *et al.*, 2007). Networks are primarily responsible for the exchange of information (Carlsson *et al.*, 2002). This is equally important for an environment where technology is diffused, as it is in an environment where strict R&D activities occur. When generated knowledge is transferred through the whole network, it creates an opportunity for system-level learning to take place. This has a positive impact upon technology development and the decimation of technology through the system (Hekkert, Harmsen and de Jong, 2007). Wieczorek *et al.* (2015) state that the diffusion of knowledge can be of equal importance to the development of novel or improved products or services as the actual process of generation of these products or services. In fact, it is stated that successful innovators are often firms that best utilize knowledge generated by others for their commercial ideas (Wieczorek *et al.*, 2015). Indicators of knowledge diffusion activities within an innovation system include training activities, demonstrations (Tigabu, Berkhout and van Beukering, 2015b), conferences, workshops, seminars and meetings, alliances between actors and exchange of information (Hekkert *et al.*, 2007) and joint ventures (Suurs, 2009).

3.4.2.4. F4: Guidance of search

This function serves a dual purpose. Firstly, it provides guidance to actors for the application of resources within the innovation system, highlighting appropriate opportunities (Hekkert *et al.*, 2007). Resources are limited and thus it is important to know where to apply them (Hekkert, Harmsen and de Jong, 2007). As a result, it is important to have a selection process that guides this decision. Establishing “expectations and visions, priority setting in R&D strategies and foresight studies” can form part of the selection process (Wieczorek *et al.*, 2015). The important actors that play a role in this function are industries, governments and markets (Hekkert, Harmsen and de Jong, 2007). Secondly, the function provides clarity, improve visibility and enhances the understanding of actors within the innovation system (Hekkert *et al.*, 2007). Indicators of guidance of search activities within an innovations system include setting policy targets, standards and research outcomes, defining expectations, providing directions or showing interest, communicate research outcomes to the public (Hekkert *et al.*, 2007), designing favourable regulations and policies, and communicating vision and expectations (Bergek *et al.*, 2008).

3.4.2.5. F5: Market formation

The activities found in this function ensure that a novel technology [or innovation] gets diffused in a protected market space. Since novel technologies are often more expensive and vulnerable than existing technologies it is necessary to diffuse the technology within a protected system to facilitate market development (Hekkert *et al.*, 2007). New technologies often struggle to compete with existing technologies when entering new markets. This is especially true for radical innovations since it often challenges an existing status-quo (Wieczorek *et al.*, 2015). As a result, it may be necessary to establish a temporary niche market to protect new technologies. Such a market enables knowledge about the technology to be developed and diffused. It also provides an opportunity for expectations to be created (Hekkert, Harmsen and de Jong, 2007). Indicators of market formation activities in an innovation system include subsidies to finance investment (Tigabu, Berkhout and van Beukering, 2015b), reforming regulations and market regulations, implement regulations supporting niche markets and setting tax incentives and tax exemptions (Hekkert *et al.*, 2007).

3.4.2.6. F6: Resource mobilisation

This function involves the alignment of resources to enable novel technologies or innovations to be developed, diffused, and used (Hekkert *et al.*, 2007). The two primary resources found in an innovation system are financial capital and human capital. Financial capital is generated either internally or externally by subsidies from government and other programs and venture capital gained from investors. Human capital refers to knowledgeable personnel within the innovation system whose competency and knowledge are developed through training and education programs. These two resources form the basis of a well-functioning innovation system and are invaluable. It is important to mobilise these resources and align them towards the correct activities so that the necessary processes (as described in the previous functions) in the innovation system are fulfilled (Hekkert, Harmsen and de Jong, 2007; Wieczorek *et al.*, 2015). Indicators of resource mobilisation activities in an innovation system include financial incentives, infrastructure developments, acquiring complementary assets (Bergek *et al.*, 2008), subsidies, investments and recruiting human resources (including consultants and technical staff) (Hekkert *et al.*, 2007).

3.4.2.7. F7: Creation of legitimacy

Since a novel technology or innovation may encounter a lack of support among key actors and stakeholders or encounter resistance to change in a market, it is necessary to raise support and develop advocacy among these role players. This function involves all activities that attempt to achieve this aim (Hekkert *et al.*, 2007; Wieczorek *et al.*, 2015). Indicators of the creation of legitimacy function in an innovation system include advocacy coalitions and all lobbying activities (Hekkert *et al.*, 2007).

3.5. Innovation for Inclusive Development Systems (I4IDS)

Innovations and resulting innovation systems of developing countries usually consist of large formal organisations that either focus on the export market, or serve the needs of a small number of high-income consumers that reside in the country (Foster and Heeks, 2013). Unfortunately, residents with a low income are usually excluded from these innovations, even though they form the majority of the national population (Van der Merwe, 2017). If these residents partake in the economic sector, it is often as informal entrepreneurs (Van der Merwe, 2017). This phenomenon is labelled as exclusion – the process where innovative activities result in greater inequalities than equality (Van der Merwe, 2017).

According to Van der Merwe (2018), “the relationship between innovation and inequality is... complex”. Piketty (2014) makes the point that innovation in itself is not the only or even the greatest contributor towards inequalities – yet it is often associated with, and an influencer of poverty and inequality as a result of different economic, social and political processes. Altenburg (2008) notes that, as the features of innovation and inequality co-evolve, innovation may often provide greater momentum for inequalities to arise and grow. On the other hand, it may cause a decrease in inequality or even cause it to be removed (Altenburg, 2008). It is clear though that an enhanced understanding of the dynamics between innovations and inequality can potentially greatly contribute to providing direction that form technological change that improve equity, equality and social cohesion (Chataway, Hanlin and Kaplinsky, 2014).

In recent times, innovation models have come to the fore, specifically within developing countries, that attempt to alleviate inequalities by focussing their attention on the structures and processes that are necessary to develop goods or services for and/or by marginalised groups, in order to enhance their economic and social wellbeing (Foster and Heeks, 2013; van der Merwe and Grobbelaar, 2018). As mentioned earlier (see Section 3.2), various terms have been suggested to name this new form of innovation aimed at inclusion of poor or marginalised groups: “Inclusive Innovation”, “Below-the-radar Innovation”, “Bottom of the Pyramid Innovation” (Foster and Heeks, 2013) and “Innovation for Inclusive Development (I4ID)” (Heeks, Foster and Nugroho, 2014).

In the literature, these terms are used to describe two primary approaches (Chataway, Hanlin and Kaplinsky, 2014; Foster and Heeks, 2015) of which both specifically focus on “inclusive development” and “shared prosperity” (Van der Merwe, 2018). Both approaches are inclusive in nature, but its inclusivity is determined along different stages of the innovation process. The first

approach views the output of the innovation process as inclusive: The output of the process is focussed on serving a particular need of the marginalised actors within the innovation system. In this way, the marginalised actors benefit from the innovation (Pralhad, Di Benedetto and Nakata, 2012; Foster and Heeks, 2014). The second approach views the development stages of the innovation process as inclusive: If the marginalised actors in the system are not benefitted by the output of the innovation process, they actively partake in the innovation process, even as partners in some cases. In this way they gather social and/or economic value from the process (Cozzens and Sutz, 2012).

Each of the terms mentioned that are used to describe the inclusive innovation process, has slight differences with regards to the target groups, innovation type and objectives of the innovation (Iizuka, 2013), however each have the same overarching aim of development of products or services for/by marginalised groups to enhance their economic and social wellbeing. Innovation for inclusive development entails the implementation of innovations in informal settings where marginalised populations live and through this process address the poor (Cozzens and Sutz, 2012). This explanation is the focus of this document and will henceforth be what is meant when referring to I4IDS.

3.5.1. Fundamental differences between conventional IS systems and I4IDS

The work of Foster and Heeks (2013) is an important contributor to the understanding of I4IDS. Among other things, they wanted to determine whether the IS perspective could be applied to inclusive innovations. They conclude that it is perfectly fine to do so, since both conventional and inclusive innovations form part of a system of actors interacting with one another to learn, develop, and partake in innovation activities within an institutional system. However, there are differences between the focal points of the components in the system, since within an inclusive innovation context, the components work together to produce innovations specifically aimed at marginalised individuals or communities to positively impact their living conditions (George, McGahan and Prabhu, 2012). The broad system focus within conventional IS, is on development of innovations that is measured by economic growth, whereas the focus is different within I4IDS with more attention given to socio-economic and micro-level aspects that aim to improve livelihoods and the quality of life for the marginalised. The system is characterised by social innovation and challenge-based approaches. These are developed as the result of societal concerns that are carried over by a diverse set of actors. (Van der Merwe, 2018)

The differences in the broader system focus and goal translate to fundamental differences between the two system perspectives and within literature, multiple fundamental differences between conventional IS and I4IDS are found: The implementation of innovations in informal settings are

often the result of a strong demand of the informal communities with the desire to improve their welfare (Chataway, Hanlin and Kaplinsky, 2014). This is the case since the desired products or services are not provided by conventional actors (Iizuka, 2013). In addition, skills that are developed among the marginalised are not necessarily the result of formal education, but often because of informal learning processes (Kraemer-Mbula and Wamae, 2010). Therefore, in an inclusive innovation system setup, the providers of knowledge and channels of knowledge flow differ from conventional IS setups (Iizuka, 2013). Furthermore, collaboration between formal and informal settings occur infrequently (Cozzens and Sutz, 2012), therefore the important role that intermediary organisations or actors play between formal and informal settings as distributors of knowledge is amplified (Mair, Martí and Ventresca, 2012). Their roles are acknowledged as necessary to provide the contact point between formal and informal markets and increase the diffusion of knowledge which in turn prepare the informal actors to innovate and prepare the informal settings to sustainably implement innovation activities (van der Hilst, 2012). Additionally, most of the innovations in developing countries are non-technological and come from incremental and organisational innovation (Cozzens and Sutz, 2012). Lastly, policies for informal settings differ from more conventional policies. The policies are focussed on benefiting the marginalised groups in the informal settings, to ultimately improve their standard of life and wellbeing (Kraemer-Mbula and Wamae, 2010; Cozzens and Sutz, 2012; Foster and Heeks, 2015).

3.5.2. Differences Between Components and Functions within I4IDS Context

Even though there are fundamental differences between the conventional IS and I4IDS perspectives, the IS perspective is still applicable to inclusive innovations (Foster and Heeks, 2013). However, since fundamental differences do exist, and because of the difference in the broader system focus, it is necessary to make some adaptations to the conventional system components and functions. These are done specifically with regards to the focus and mechanism within the components and functions, and include activities within the functions that do not necessarily form part of conventional innovation system functions. It is therefore necessary to compare the components and functions within the IS and I4IDS contexts to identify similarities and additions, particularly within I4IDS. The comparison between the actors and functions within the different contexts are given in Table 3-1 and Table 3-2 respectively.

Table 3-1 Comparison between Components of Conventional IS and I4IDS

Components	Conventional IS	I4IDS
Innovation	Innovations aimed at growth (economic in particular) that are mostly driven by supply. (George, McGahan and Prabhu, 2012)	Innovations are developed as the result of the needs of local communities and aim to address these needs. It is often incremental “demand-driven” and “non-technical” innovations, with the intent of solving community-based problems through collaboration between multiple partners (Altenburg, 2008; George, McGahan and Prabhu, 2012; Foster and Heeks, 2013). The marginalised are then included as part of the process or in the eventual output (Altenburg, 2008).
Learning	Primarily set up to focus on higher income people groups, formal actors in industrial sector (particularly supply-side organisations) and intermediaries acting as R&D brokers (van der Merwe, 2018). Forms of learning include learning-by-doing, learning-by-using, and learning-by-interacting (George, McGahan and Prabhu, 2012).	The content of the knowledge is context-specific, particularly focusing on the needs of the marginalised, with special attention on diffusion. Learning of social processes, informal markets, processes of inclusive development and the inclusion of marginalised actors within the innovation system in a sustainable manner, are present with increasing regularity. (Chataway, Hanlin and Kaplinsky, 2014; Foster and Heeks, 2014)
Actors	Primarily constitutes formal participants that are somewhat static, specifically, formal institutions, that play a big role in the supply-side. R&D brokers fulfil the role of intermediaries. (George, McGahan and Prabhu, 2012; van der Merwe, 2018).	Broadened range of actors, which means that non-traditional actors join the system, most notably as actors on the demand-side of the system (George, McGahan and Prabhu, 2012). These include intermediaries, marginalised groups and innovators (Foster and Heeks, 2013; Kuhlmann and Rip, 2015). The focus is primarily to include the marginalised as actors, both as individuals and communities to promote participation (van der Merwe, 2018).
Interactions	Primarily formal and focus on applications of learning about technologies, production, and implementation. Primarily motivated by coherence and maximising profits. (George, McGahan and Prabhu, 2012; van der Merwe, 2018)	Informal and social relationships between conventional and non-conventional actors, often on a deeper level than typical business relationships (George, McGahan and Prabhu, 2012; Foster and Heeks, 2013; Kuhlmann and Rip, 2015).
Institutions	Primarily formal institutions with formal rules and policies that inform the actions of system actors (George, McGahan and Prabhu, 2012).	Complexed institutional setup that is a combination of formal and informal institutions. Institutions play an important part in the formation of regulations that enable novel innovations to be implemented. (George, McGahan and Prabhu, 2012; van der Merwe, 2018).

Table 3-2 Comparison between Functions of Conventional IS and I4IDS

Function	Conventional IS	IIS
Entrepreneurial Activity (F1)	Exploiting business prospects (knowledge generation, novel markets and technologies) mostly among high-income markets (Hekkert, Harmsen and de Jong, 2007; Wieczorek <i>et al.</i> , 2015; van der Merwe, 2018).	Unconventional actors are included and partake in the system as providers and diffusers of knowledge throughout the complete duration of the innovation process (Kuhlmann and Rip, 2015). The existing business models are formed to focus on the target community specifically. Furthermore, the marginalised community is provided with the opportunity to be part of the innovation process (Chataway, Hanlin and Kaplinsky, 2014).
Knowledge Development (F2)	Generation of knowledge occurs mostly because of formal R&D activities and experience (learning-by-doing, learning-by-using and learning-by-interacting) or other formal instances. (Wieczorek <i>et al.</i> , 2015; van der Merwe, 2018).	Knowledge encapsulates both market pull and push strategies (Foster and Heeks, 2013). Pull strategies are focussed on the needs of the marginalised and push strategies focus on the sectors that are beneficial to the marginalised. Knowledge, capacities, development and collaboration are prioritised and focussed on extensively (Cozzens and Kaplinsky, 2009). The development of formal knowledge is focussed on the livelihoods of the marginalised groups (van der Hilst, 2012).
Knowledge Diffusion (F3)	Supply-side and demand-side mechanism work together to allow increased knowledge flow that enable innovative activities (van der Merwe, 2018).	There is a special focus on diffusion, in particular the ability of information to be taken up and used in the I4ID setting (Iizuka, 2013). Special attention is given towards identifying and developing new diffusion channels that may not be as clear as with conventional ISs (van der Merwe, 2018).
Guidance of Search (F4)	Assist in identifying fitting technology or projects to invest in by offering direction for formal actors (Hekkert <i>et al.</i> , 2007; van der Merwe, 2018).	Like conventional ISs, it is necessary to cultivate belief in the growth potential of the innovation/project. Set well-defined and achievable targets. Create incentives to assist the establishment of emerging markets and the orientation of governmental policies that cultivate inclusive development. (Hekkert <i>et al.</i> , 2011)
Market Formation (F5)	Mechanisms to prepare an environment which allows for successful innovation development and uptake. (Hekkert <i>et al.</i> ,	A shift in the central foci of the project: from product-centric to business model innovation of which the product simply form part (van der Hilst, 2012). Since systems thinking is integral to the successful functioning of innovation in marginalised groups (Kuhlmann and Rip, 2015), renewed and special attention

	2007; Hekkert, Harmsen and de Jong, 2007; Wieczorek <i>et al.</i> , 2015; van der Merwe, 2018)	to establish a system as part of the innovation, is crucial. Special government effort may be necessary to develop spaces that support inclusive innovation by being “market-ready” (Kraemer-Mbula and Wamae, 2010).
Resource Mobilisation (F6)	Provide guidance for acquiring and orienting human, physical and financial resources to enable the success of “mainstreamed innovation” (van der Merwe, 2018).	Acquiring and orienting resources (infrastructure, human resources, technologies etc.) to function in the uniquely constrained marginalised market (Foster and Heeks, 2014).
Creation of Legitimacy (F7)	Develop structures that develop legitimacy to advocate for or strengthen the commitment from governmental authorities or actors within the private sector to support innovations (van der Merwe, 2018).	Develop legitimacy regarding the potential of the innovation/project within a market. Special attention and focus to develop legitimacy around the potential benefit of the innovation/project among the marginalised. Collaboration and engagement by the formal actors with the marginalised community and the establishment of trustworthy relationships. Provide evidence for benefit of interventions for both formal actors and marginalised groups. (Van der Merwe, 2018)

3.5.3. Functions within I4IDS Context

The different focal points within the IS and I4IDS perspectives (illustrated in Table 1 and Table 2) mean that activities between the components (that translate to system functions) are differently orientated in I4IDS when compared to IS. The basis of the functions remains the same, but the added complexity within I4IDS means that additional activities often occur. The functions in the I4IDS are discussed next.

3.5.3.1. F1: Entrepreneurial activity

For an IS to prosper, it is crucial to offer entrepreneurial opportunities to the actors in the system, since the performance of the IS is dependent on these activities. Together with these opportunities, human and financial resources most often are also present, since they make the opportunities possible (Hekkert *et al.*, 2007; van der Hilst, 2012). Therefore, it is important within an I4IDS that it is setup in such a way that marginalised actors can engage in formal and informal market settings (Foster and Heeks, 2013). It is also important that the other system functions strengthen entrepreneurial activities within the system to allow the marginalised actors to have access to funding. Incentives are promoted to include the marginalised actors as business partners (through local entrepreneurial activities) within the business model or programme (Chataway, Hanlin and Kaplinsky, 2014). In addition to typical indicators found within conventional innovation systems, indicators of entrepreneurial activity, specifically found within the I4IDS context, include the following:

- Inclusion of marginalised community within business models (van der Hilst, 2012).
- Opportunities for marginalised partake in innovation development (Chataway, Hanlin and Kaplinsky, 2014; Grobbelaar and van der Merwe, 2016)
- Providing loans and funding to marginalised groups (van der Merwe, 2018).
- Projects with clear goals of sustainable inclusive entrepreneurship (van der Hilst, 2012).

3.5.3.2. F2: Knowledge development

The lack of knowledge (information poverty) is said to be the biggest obstacles to sustainable development (Prahalad and Hart, 2002). Organisations that function or plan to function within marginalised markets, must carefully consider how knowledge will be included for the use of participating marginalised communities – in both the design process and development of the innovation. It is therefore important that this is addressed early on in the innovation process (Kaplinsky, 2011). Worldviews of companies in formal settings differ from those of less formal communities, and it is therefore important to make an effort to understand the contexts of the marginalised communities and understand their way of living, in order to best include these

communities in innovation processes that serve their needs (Ismail, Ansell and Kleyn, 2012). Indicators of knowledge development activities within I4IDS context include:

- Market-pull strategies that take requirements of the marginalised into account, and market-push strategies that focus on sectors of most value to marginalised (Thorpe, Mathie and Ghore, 2017).
- Using marginalised actors as knowledge providers (Trojer, Rydhagen and Kjellqvistt, 2014),
- Considerations of literacy, capabilities and capacity of marginalised groups in design and development of innovations (Trojer, Rydhagen and Kjellqvistt, 2014; van der Merwe, 2018)
- Focussing on knowledge, development and collaboration, and revise or develop formal knowledge so that it focusses on marginalised livelihoods (van der Hilst, 2012).
- Collaboration occurs between formal and informal research organisations (van der Hilst, 2012; Clifford and Zaman, 2016).
- Offering various forms of training and development to marginalised groups (van der Hilst, 2012).

3.5.3.3. F3: Knowledge diffusion

The knowledge diffusion function in its simple form encompasses the activity of flow of knowledge throughout the innovation system (Hekkert *et al.*, 2007), from innovator to end-user. In informal settings, this function is particularly important if the I4ID wants to achieve its beneficial intentions – without good knowledge flow among the actors it will be very difficult to do so, and multiple examples of failed innovation ventures exist as a result thereof (Ismail, Ansell and Kleyn, 2012; Chataway, Hanlin and Kaplinsky, 2014). It is crucial to establish novel channels of knowledge flow with marginalised actors that are involved in the innovation system, particularly those that are respected within their communities (van der Merwe and Grobbelaar, 2018). Indicators of knowledge diffusion activities within I4IDS include:

- Emphasis on ability of diffusion of important information to enhance I4ID (Peerally, de Fuentes and Figueiredo, 2019)
- Creation of platforms for informal and formal sector actors to engage (Trojer, Rydhagen and Kjellqvistt, 2014)
- Development of knowledge channels between informal and formal sector actors (Trojer, Rydhagen and Kjellqvistt, 2014)
- Translating important knowledge into local language of marginalised group (Trojer, Rydhagen and Kjellqvistt, 2014)
- Removing barriers that hinder communication between marginalised community actors and other actors in the system (Trojer, Rydhagen and Kjellqvistt, 2014)

- Knowledge of marginalised group is considered as a core influence for decisions by top decision makers (Clifford and Zaman, 2016)
- Using marginalised actors as distributors of knowledge within the marginalised community (Clifford and Zaman, 2016)

3.5.3.4. F4: Guidance of search

In general, there are constraints related to resources aimed at identifying worthy ventures of future investments (Hekkert *et al.*, 2007), and in I4ID this is no different. Oftentimes I4ID ventures fracture if higher level planning is not done properly (van der Hilst, 2012). Major uncertainties are often present in emerging markets (certainly more than in established markets) and this increases the importance for activities that advise and support guidance of search in the innovation system (Altenburg, 2008; Kraemer-Mbula and Wamae, 2010). Indicators of guidance of search activities within I4IDS include:

- Government policies oriented toward inclusive development (van der Hilst, 2012)
- Setting clear and achievable targets (van der Hilst, 2012)
- Enhancing belief in the potential of a project (Bergek *et al.*, 2008)
- Policies formed to enhance empowerment and capabilities of marginalised groups (van der Hilst, 2012)

3.5.3.5. F5: Market formation

Within I4ID the focus should not solely be on innovations and supply-side factors such as innovating solutions or funding for ventures. It is equally important to consider the demand-side, where markets for the innovation need to be established for whichever products or services are offered. In addition to the product-centric focus of more conventional innovation systems, I4IDS is required to go beyond this with additional areas of focus and thinking. The I4IDS framework provides guidance to promote both formal and informal markets, particularly where goods or services – either provided by or for – the marginalised to prosper. (Kraemer-Mbula and Wamae, 2010; Prahalad, Di Benedetto and Nakata, 2012; van der Merwe, 2017) Indicators of market formation activities within I4IDS include the following:

- Special governmental efforts to develop environments that support I4IDS and to prepare the market for successful uptake of innovation (van der Hilst, 2012; Trojer, Rydhagen and Kjellqvist, 2014)
- Provide visibility of innovation to actors (Trojer, Rydhagen and Kjellqvist, 2014)

3.5.3.6. F6: Resource mobilisation

In conventional innovation system, resource mobilisation encompasses all activities focussed on making human, financial and physical resources available. Since resources (particularly human and financial) are usually more constrained in informal settings (Foster and Heeks, 2014), this function requires adaption for I4IDS that carefully considers how to make resources more accessible and easier to use (van der Hilst, 2012). Indicators of resource mobilisation activities within I4IDS include the following:

- Incentives for successful scaling of programme or innovation encouraging local entrepreneurs to actively take part (van der Merwe, 2018).
- Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID (Swaans *et al.*, 2014)
- Alignment of resources to the needs of the system (van der Hilst, 2012)
- Acquiring technological infrastructure and/or human resources among the marginalised (van der Merwe, 2018).

F7: Creation of legitimacy

I4IDS is not except from scepticism, resistance and doubt that often accompanies new innovations in traditional innovation systems (Bergek *et al.*, 2008; van der Merwe, 2018). Oftentimes, these translate to doubt on the side of formal actors about the potential of the novel innovations and the positive effect that it will have among the marginalised, as well as distrust from the marginalised actors (Chataway, Hanlin and Kaplinsky, 2014). It is therefore necessary to change these perceptions to improve the probability of the success of I4IDS. Indicators of creation of legitimacy activities within I4IDS include:

- Build legitimacy around the effect of interventions within marginalised groups (van der Merwe, 2018).
- Engagement with marginalised groups and forming trustworthy relationships (van der Hilst, 2012)
- Provide evidence for benefit of interventions for both formal actors and marginalised groups (van der Merwe, 2018).

3.6. Chapter Summary

In this chapter, innovation systems literature is reviewed and discussed. It starts with introducing the concept of innovation (Section 3.1) and the role of innovation among the marginalised (Section 3.2). Next, the history and evolution of the innovation process model to the current systems model of

innovation (referred to as the IS perspective) is explained in Section 3.3 along with the different applications of the perspective, based on the settings of the system. In Section 3.4 the components and functions of the IS perspective are reviewed. The I4IDS perspective is discussed in Section 3.5 and the focus points of the components and functions between the IS and I4IDS perspectives are compared. Lastly the additions to the system functions from the I4IDS perspective are reviewed and the indicators of the functions in I4IDS is provided in this section.

Chapter 4

Analytical Framework and Analysis

Synthesis

In this chapter, the analytical approach to analyse the case studies in this project is explained. It draws on the work of Suurs (2009) who applied the EHA research method (See Section 2.1) to innovation systems and formulates the five-step approach.

4.1. Event History Analysis

The six-step EHA method that guides the development of the EHA analytical framework is first introduced in Section 2.1. As mentioned in Section 1.4, because this research project specifically focusses on the functions of the I4IDS perspective, the analysis of the system components falls outside the scope of this project. Therefore, the EHA method is adapted to a five-step analytical framework. The five steps are illustrated in Figure 4-1.

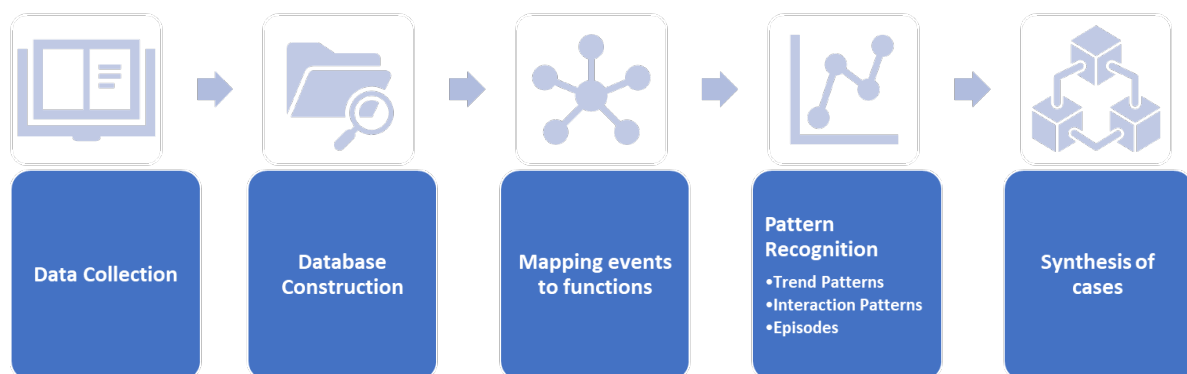


Figure 4-1 Five Steps of EHA Framework

The EHA framework is used in this study to analyse the three case studies in Chapter 5 (Mafarafara case), Chapter 6 (ICT4RED case) and Chapter 7 (SVS case), and then to synthesise the findings of each case to ultimately construct the final I4IDS CLD, illustrating the common narrative.

The application of the EHA framework to construct the final I4IDS CLD is as follows: The first four steps of the EHA framework (See Figure 4-1) are applied to each case separately. As a result, each case has its own findings that are used to construct a CLD for each case. During the last step of the EHA framework, the findings of each case are synthesised to derive

communal findings between the cases that are grouped together based on similar objectives and key activities. For each of the communal findings, a CLD is constructed that illustrates the communal narrative. Lastly, these narrative stories are combined to construct the final CLD that represents the full narrative story of the collective I4IDS that is informed by the three cases. This process is illustrated in Figure 4-2 and explained in the following sections.

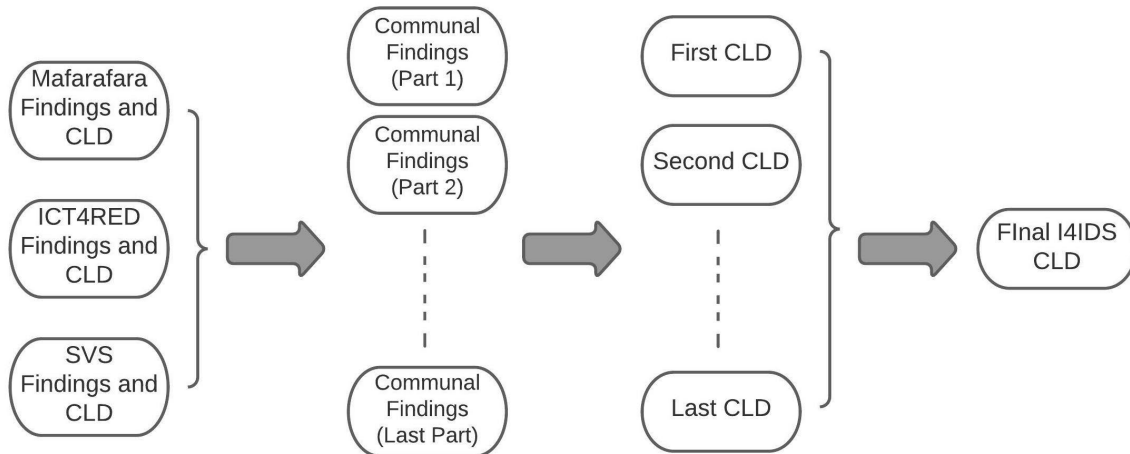


Figure 4-2 Application of EHA Framework to Construct I4IDS CLD

4.1.1. Data Collection

Various sources are consulted to gather data of the cases that are investigated. These sources include thesis documents, reports, papers, books, web sites and news reports.

4.1.2. Database Construction

The data gathered in the previous step are carefully considered to identify events. The events are placed in a database and sorted chronologically. Some of the literature where the data is gathered from, already include events in chronological order, or attach specific time stamps for the events. This makes it easier to sort the events chronologically. In other instances, this is not the case. Then, the combination of resources is used to interpret the timing of the events. For example, one source outlines the different phases of the specific case in sequential order, whereas another source discusses the events for the phases in greater detail, without attaching time stamps. In this case, the different literature sources are used to interpret the sequence of the events of the case. An event ID is assigned to each event after it has been sorted chronologically. As a result, the event IDs are reminiscent of the sequence in which the events took place.

4.1.3. Mapping events to IS functions

During this step, the events from the database are related to the applicable function or functions of the IS framework that it fulfils. The literature study in Chapter 3 covers the IS and I4IDS frameworks, to gather an in-depth understanding of the system functions of both frameworks. The literature in this chapter is used to construct Table 4-1 and Table 4-2 that contain different indicators: The general description of the particular system function (See Section 3.4.2), the identified I4IDS additions (Sections 3.5.2 and 3.5.3) and example activities of the function found in the IS and I4IDS frameworks (Sections 3.4.2 and 3.5.3) that guide the process of relating the events to the correct functions they fulfil. Each event in the constructed database (See Section 4.1.2) is compared to the indicators provided in the tables to determine if a specific event leads to the fulfilment of a function or multiple functions. Should an event fulfil a function or functions, the indicator or indicators used to do the relation is given.

Table 4-1 Indicators of Functional Fulfilment for Entrepreneurial Activity, Knowledge Development and Knowledge Diffusion System Functions

Functions	F1: Entrepreneurial Activity	F2: Knowledge Development	F3: Knowledge Diffusion
General description	Commercial or entrepreneurial activities linked to innovation or technology.	Activities that result in the development or generation of knowledge.	Activities where information is diffused among actors.
I4ID additions	Business models including marginalised - provide opportunities for marginalised to engage in business activities on formal and informal front.	Inclusion of knowledge specifically for marginalised - focused on livelihood of community.	Focus on ability of knowledge to be taken up by marginalised. Special attention to develop unconventional knowledge channels.
Example activities	<p>IS framework:</p> <ul style="list-style-type: none"> - Projects with commercial aims - Demonstrations - Portfolio expansions - Entry of firms - Manufacturing and/or constructing and/or installing technology <p>I4IDS framework:</p> <ul style="list-style-type: none"> - 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 	<p>IS framework:</p> <ul style="list-style-type: none"> - Academic research - Studies - Market surveys - Feasibility studies - Pilot projects - Developing promotional materials - Developing prototypes - Testing of model performance - Adapting model - Assessing availability of raw materials for production of technology - Conducting impact analysis - Technology literacy of entrepreneurs - Learning-by-doing <p>I4IDS framework:</p> <ul style="list-style-type: none"> - Market-pull strategies take requirements of marginalised into account - Market-push strategies are focused on sectors of most value to marginalised - Focusing on knowledge, development, and collaboration - Formal knowledge focus on marginalised livelihoods 	<p>IS framework:</p> <ul style="list-style-type: none"> - Training activities - Alliances between actors - Joint ventures - Setting up branch organizations - Awareness campaigns - Conferences, workshops, seminars, and meetings - Demonstrations <p>I4IDS framework:</p> <ul style="list-style-type: none"> - 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 - 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

		<ul style="list-style-type: none">- 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	<ul style="list-style-type: none">- Translating important knowledge into local language of marginalised group- Removing barriers that hinder communication between marginalised community actors and other actors in the system
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Table 4-2 Indicators of Functional Fulfilment for Guidance of Search, Market Formation, Resource Mobilisation and Creation of Legitimacy System Functions

Functions	F4: Guidance of search	F5: Market formation	F6: Resource mobilisation	F7: Creation of legitimacy
General description	Activities that provide clarity, improve visibility and enhances understanding of actors.	Efforts to establish an environment which allows for successful innovation uptake.	Activities involving the mobilisation and alignment of resources.	Activities aimed at raising support and advocacy for novel innovation/technology.
I4ID additions	Special incentives that cultivate inclusive development.	Broadened thinking - Inclusion of demand-side factors in addition to supply-side factors (innovating solutions or funding). Promotion of formal and informal markets.	Adaptions to conventional methods to make resources more accessible and easier to use for marginalised.	Focus on raising legitimacy around I4ID ventures. Focus on establishing and cultivating relationships between formal and informal actors.
Example activities	<p>IS framework:</p> <ul style="list-style-type: none"> - Setting policy targets, standards and research outcomes - Designing favorable regulations and policies - Defining expectations - Promises - Communicating vision - Providing directions or showing interest - Communicate research outcomes to the public <p>I4IDS framework:</p> <ul style="list-style-type: none"> - 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 	<p>IS framework:</p> <ul style="list-style-type: none"> - Subsidies (i.e., sharing cost of investment) - Market regulations - Regulations supporting niche markets - Setting tax incentives and tax exemptions - “Obligatory use” - Public procurement - Reforming regulations - Expectation <p>I4IDS framework:</p> <ul style="list-style-type: none"> - Provide visibility of innovation to actors - Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation 	<p>IS framework:</p> <ul style="list-style-type: none"> - Financial incentives - Subsidies - Investments - Infrastructure developments - Recruiting human resources - Providing equipment <p>I4IDS framework:</p> <ul style="list-style-type: none"> - Incentives for successful scaling of program 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 	<p>IS framework:</p> <ul style="list-style-type: none"> - Lobbying activities - Advice - Advocacy coalitions <p>I4IDS framework:</p> <ul style="list-style-type: none"> - 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

4.1.4. Pattern Recognition

Interaction Patterns, Episodes and Phases

Based on the outcome of the fulfilment of the functions on the previous step, the events of the case are divided into episodes. As is mentioned in Section 2.1.4, it is possible to identify an episode based on the specific functions that are fulfilled at a certain time, the patterns of the functions being fulfilled, or important background information and factors. The activities and subsequent events that take place in the case are usually concentrated and aimed at achieving specific objectives or desired outcomes throughout the development of the case. If this changes, and the objectives or desired outcomes shift, it can indicate a change in episodes. For example, at the beginning of a case there may be a big emphasis on preparation steps: Extensive research is done to develop the technology and identify a suitable target audience, models are developed to guide the implementation of a project, a core project team is assembled etc. Once all the preparation steps are done, the emphasis shifts towards making contact with the target audience, obtaining their buy-in and beginning to offer training. The shift in desired outcomes or objectives clearly indicates the start of a new episode and the end of the former. Therefore, both the objectives (and desired outcomes) and the grouping (or concentration) of similar events are used to identify the different episodes in the cases.

Going forward, it is necessary to clearly distinguish between different *phases* and *stages*. Throughout the analysis of the different cases described in the following chapters, the different episodes are referred to as *phases*. However, it may be that similar *phases* take place at different times as the case evolves over time. This usually occurs when the same project is implemented among different communities of the target audience at different times. For example, to test the feasibility of a project, it is first implemented within a small group of the target audience, and preparation steps are done during a *preparation phase*, before the implementation takes place. Once preparation is done, buy-in from the target audience may be required and the case moves towards a *buy-in phase*. This is followed by providing training and therefore the case evolves towards a *training phase*. The project then proves to be a success, and it is aimed to implement the project among another group of the target audience. The case then moves back to a *preparation phase*, followed by *buy-in* and *training phases* before the project is again implemented among the next target audience group. These different periods are referred to as *stages*. Therefore, in the example mentioned above, *Stage 1* refers to the testing period where

the project is implemented among the small group of the target audience, *Stage 2* refers to the second time the project is implemented among a different target audience group and so forth.

Once the case is divided into phases, it is possible to explain the results and identify interaction patterns in the form of sequences of resulting events and sequences of functional fulfilment. To do this, the events that take place during each phase are stated in the context that they occur in order to better understand how specific events influence others. To assist with this, an events map is used to visually illustrate the fulfilment of functions as the phase evolves, using circular grouping for similar events and arrows to show how the fulfilment of specific functions influence the fulfilment of other functions within the phase. An example of such an events map is demonstrated in Figure 4-3. In this example, the first five events (preparation steps) are similar and therefore they are grouped together and encircled. These events then result in the next two events (formation of the project team) as the first arrow indicates, that in turn results in the next event (explanation of the project to stakeholders) as shown by the second arrow.

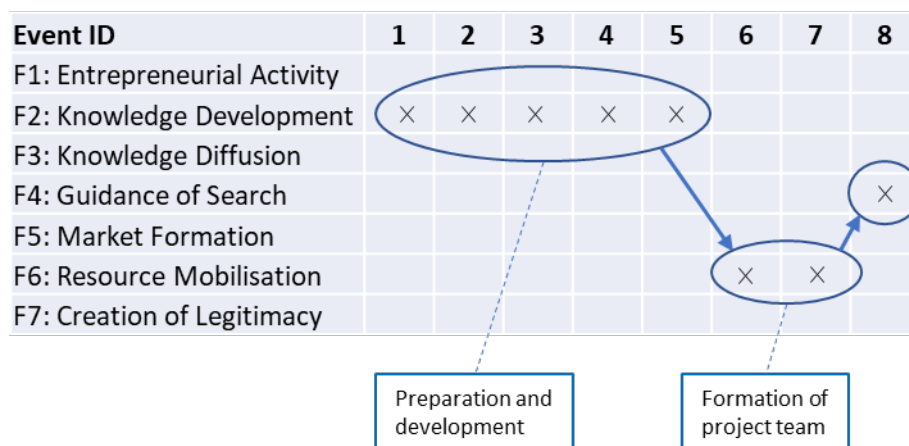


Figure 4-3 Example of Events Map

For each phase, it is then possible to conclude what are the important events that are being emphasised to obtain the desired outcomes, how the different events influence one another and what the pattern of functional fulfilment of the particular phase is. As previously mentioned, it may be that the same phase takes place across multiple stages. If this is the case, it is found that the core group of events are often similar, since the different stages have the same desirable outcomes. Therefore, the resulting events and functional fulfilments are mostly the same. There are however often unique occurrences in each stage that occur as the context of the different stages differ slightly. These unique occurrences are often very insightful and helps to give a more holistic picture of the particular phase.

As the particular case develops, different system functions are activated as the project evolves throughout the different phases – not only individually but as part of causation chains, where the fulfilment of one function through an event would result in the fulfilment of another function through a different event. It is therefore possible to draw on the event sequence maps and use causal loop diagrams (CLD) to visualize and reflect on the core causation mechanisms and elaborate on the key insights produced by feedback loops of system functions throughout the phases. Feedback loops emerge when a set of at least two system functions create a reinforcing relationship of cause–effect between one and the other. Therefore, in conclusion of a case, the different feedback loops are used to construct an overall CLD of the case, visually illustrating how the different functions developed throughout the phases.

Trend Patterns

In the process of assigning functions to the events, the outcome is one of four possibilities:

- An event leads to the fulfilment of a function. In some cases, a particular event leads to the fulfilment of more than one function.
- An event does not lead to the fulfilment of any function. This mostly happens when such an event is simply stated to provide context for other related events. In his research work, Suurs (2009) states that all events that constitute the database of a particular case will result in the fulfilment of one of the seven functions. However, in his work, the cases were studied over many years, and because of the infinite number of events that would then make up a case should it be analysed on the same level as the cases being analysed in this research project, it would simply take too long. Seeing that the cases analysed here are on a different level, it is sometimes necessary to include an event in the database to provide context for the following events. The result is that these events do not always lead to the fulfilment of any of the seven functions.
- An event has a blocking effect on the fulfilment of a function. In this case no values are added or subtracted from the total value of the related function, but it is noted and can be identified as an important blocking mechanism to consider.
- An event has an adverse effect on the fulfilment of a function, in other words it reverses and breaks down the positive effect of other events on a particular function. Similar to events having a blocking effect, should an event have an adverse effect, no values are added or subtracted, but it is noted.

To track the trend patterns in the case, a numerical value of zero is assigned to each function at the beginning of each case. Whenever an event fulfils a particular function, a value of +1 is added to the accumulating total of the function. If an event leads to the fulfilment of more than one function, all the related functions get an added value of 1. As the case develops, the accumulating totals of the functions increase. At the conclusion of the case, these values are plotted over time to show the trend pattern.

4.1.5. Synthesis of different cases

The final step of the EHA Research Method is the process of synthesising the outcomes of the different cases. This is done to present a general insight into the functional dynamics that are present among the cases, as well as the way that they develop in the form of CLDs, and then construct a final CLD that illustrates the development of the I4IDS as represented by the findings of the three cases.

In this final step the different phases from the different cases are compared and phases with similar objectives, outcomes and key activities are grouped together to form common phases that are present across all the cases. Once the different phases have been grouped together, it is possible to identify a common narrative between them by identifying similar fulfilment of functions that result in similar causal chains. The causal chains are then combined to form feedback loops that are used to construct the CLDs that represent the general functional dynamic of the particular common phase. The CLD of each phase then informs the narrative of the I4IDS that draws on the findings of the synthesised functional dynamics to construct a final CLD.

As mentioned in Section 2.1.6, the presence of causal cycles (CLDs) and their developments are strengthened by replication, but because the cases are unique in some degree, it is expected that there will be differences between the phases. Although a common narrative should be identified between the three cases that is strengthened by repetition, the unique outcomes give valuable insight and can be seen as supportive of the common narrative. Together the common narrative and the unique insights form the CLD for that phase. Once this is done, the events within the phases are compared to identify similar fulfilment of functions that result in similar causal chains. The causal chains are then combined to form feedback loops that are used to construct the CLD that represent the general functional dynamic of the specific phase.

4.2. Chapter Summary

In this chapter, the EHA framework is explained that is used to analyse the three case studies in the next three chapters and to synthesise the findings between them in Chapter 8. Section 4.1.1 explains the data collection process to be followed that results in the construction of a database consisting of events as explained in Section 4.1.2. Section 4.1.3 describes how the events are related to the different innovation system functions that they fulfil. Section 4.1.4 explains how the events are used to identify phases within a case and how interaction and trend patterns are identified within the phases. Lastly, Section 4.1.5 explains the synthesis process between different cases to identify general functional dynamics (resulting in CLDs) across the analysed cases.

Chapter 5

Case A: Mafarafara

In this chapter, the first of three case studies is analysed using the analytical approach discussed in Chapter 4. An introduction of the case study is provided in Section 5.1. Within Section 5.2 the events of the case are related to the functions they fulfil, the case is divided into eight phases and for each phase an events map is given to identify the causal chains and feedback loops of the specific phase. In Section 5.3, the causal chains and feedback loops are used to construct a CLD of the case that illustrate the narrative of the core dynamics identified as the case evolved over time. Some sections in this chapter have been previously used in a journal article published by the author of this project – See Berno Maarsingh, Sara S. Grobbelaar, Mauricio Uriona-Maldonado & Marlien Herselman (2021) Exploring functional dynamics of innovation for inclusive development: event history analysis of an ICT4D project, *Innovation and Development*, DOI: 10.1080/2157930X.2021.1956712

5.1. Introduction to Mafarafara Case Study

The project is conducted within the Mafarafara community with the purpose to co-create an ICT platform as part of the Digital Doorway (DD) initiative. The DD initiative was started in 2002 and funded by the South African Department of Technology to see whether unsupervised learning was possible to aid the development of computer literacy skills within rural communities (Gush *et al.*, 2010). The DD is a computer-based kiosk which communities can use to access information of various sorts. The information loaded onto the DD are mostly in English and come from sources such as Wikipedia, Gutenberg books and library books. Also added onto the DDs are educational games.

As the DD initiative developed, a priority was identified to focus on women and agriculture. As a result, Mafarafara is chosen as an agricultural community with a high number of socio-economically disadvantaged elderly rural women (ERW) who might benefit from using an ICT platform that incorporates previous DD's technology. The intention was to modify the technology as it would be co-created with the ERW as target audience during the project. The project's entry point into the community is through the establishment of a relationship with a local community leader known as Mma C. She is fluent in English and could take up the role of cultural interpreter and project champion. (Smith, 2019)

Initially 25 ERW volunteers take part in the project, but by the third research visit, the participant numbers stabilise at 11. The ICT platform is installed in the Setsong community centre which members of the community built themselves. The building was used by the ERW as a communal gathering place, mainly for sewing. After the installation of the ICT platform, the centre is also used for working on the platform. During the seventh research visit it is discovered that the community centre housing the ICT platform is damaged by a storm beyond repair. As a result, a new centre will have to be built. When building the initial centre, the Mafarafara community made their own bricks and use that to build the centre. Since the community of Mafarafara is a resource-constrained community, this process of building will be used again, but it is a time-consuming process and has not been finished at the time of documenting the case. (Smith, 2019)

5.2. Data Analysis

The data for this case is primarily gathered from a thesis document written by Smith (2019). Within this document various site reports are found, and the observations of other authors are also reported. The case consists of seven site visits (referred to as research visits) where the research team was present during the visit to record data, and smaller visits in-between (known as technical visits) to install, maintain or update the ICT platform - during these visits, the research team was not present.

The dates for each visit is very specific (except for the visit in-between the fifth and sixth site visit) and is reported in Table 5-1, along with the description of the visits.

Table 5-1 Description of Site Visits to the Mafarafara Community

Timeframe	Date	Description
Before first visit	-	All activities preceding the first visit to Mafarafara.
First research visit	22-25 April 2013	Obtain buy-in from community and do baseline needs analysis.
Technical visit	19 June 2013	Inspection by technical team.

Second research visit	19-23 August 2013	Install ICT platform and give training for participants.
Third research visit	25-27 November 2013	Have follow-up interviews with women identifying what worked, what did not and what changes are necessary for the physical design and content of ICT platform.
Between third and fourth visit	February 2014	Technical visit to install upgraded solar panels and update information on ICT platform.
Fourth research visit	1-4 April 2014	Get feedback on usage of ICT platform from elderly women and increase understanding of womens' everyday life.
Fifth research visit	22-26 August 2014	Get feedback on usage of ICT platform from elderly women and increase understanding of womens' everyday life.
Between fifth and sixth visit	Not specified	Remove ICT platform to install upgrades.
Sixth research visit	20-24 April 2014	Reinstall updated ICT platform and train participants regarding updated features.
Seventh research visit	23-26 October 2016	Inspect damage to ICT platform and community centre after a storm.

The events that took place during the visits are well reported with very specific dates, which are accurate to the day of occurrence. The minority of events are not reported in this manner. However, it is clear during which month and year it occurred as well as the order of occurrence of these events during a visit. As a result, the events are added within a database and sorted in chronological order. Thereafter, for each event, it is determined whether that event leads to the fulfilment of a function or multiple functions according to the process explained in Section 4.1.3. The outcome of this is given in Table 10 in Appendix A. Based on the results and the background information, this case is divided into eight phases that group together the different research visits and technical visits.

5.2.1. Phase 1: Pre-engagement Project Preparation Phase

The ICT platform is developed before any engagement with the target audience takes place. Research is conducted to determine the appropriate community with the necessary ERW requirements (Both F2/KDEV). Before a visit could be made to the Mafarafara community, ethical clearance is obtained from the necessary research institutes (F2/KDEV) and the interview guidelines are developed (F2/KDEV). Ethical documentation includes informed consent forms and permission by the chief of the Mafarafara village (F2/KDEV). Training material is finalised (F2/KDEV). The research process is tested through a pilot study that use the ethically developed documentation and processes among a group of women with prior experience of the DD and a similar profile to the ERW of Mafarafara (in terms of age and socio-economic conditions) (F2/KDEV). Based on the pilot study, the documentation is finalised (F2/KDEV). The necessary documentation is sent to Mma C via email and telephonic follow-ups are done, explaining the necessity of the consent forms and explaining the processes of the project and introduce the members of the research team (F3/KDIF and F4/GOS). Through the leadership of Mma C, the ERW agree in principle to partake in this project (F1/EA) and Mma C sanctions the project (F7/COL).

The events map of Phase 1 is given in Figure 5-1. Firstly, thorough research is conducted to establish key information related to the project. These include the following: Developing the technological infrastructure to be used in the project, identify a suitable community wherein the specified target audience is found and testing the developed technological infrastructure (F2/KDEV). Thereafter, further preparation can begin by obtaining ethical clearance, developing interviewing structures and training material, piloting the ethical process and finalizing ethical documents (F2/KDEV). Once this has been established, collaboration with the target audience is important (F3/KDIF). This allows the project team to explain what the purpose of the project is, its vision and what is to be expected from the target audience, which results in an enhanced belief in the project's ability among these informal actors (F4/GOS). In turn, this leads to a willingness from the marginalised community's side to partake in the project (F1/EA). Adding to this, a leader from the target audience sanctions the project, which highlights the fact that trustworthy relationships have started to form (F7/COL).

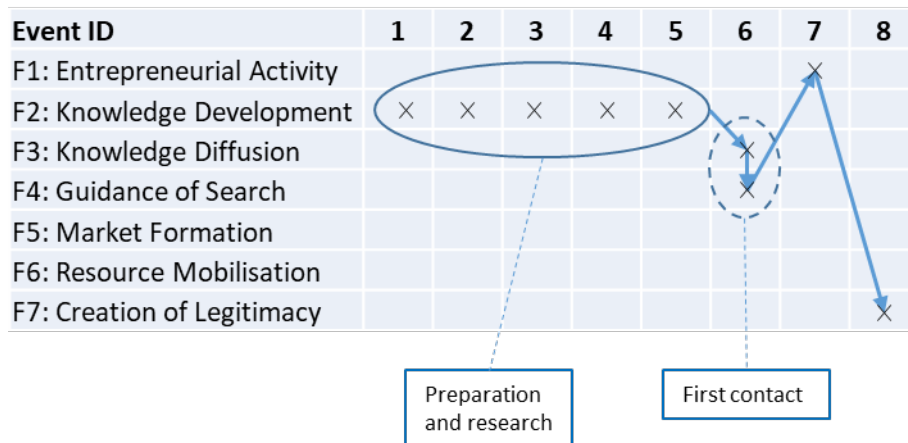


Figure 5-1 Events Map of Phase 1

This phase illustrates that in the beginning of the project, there is a big focus on knowledge development activities (F2/KDEV). This can be expected, particularly since this project is research-based. This indicates that, before any project of this sorts can be initiated or contact is made with a target audience, proper preparation is vital. This includes research activities, obtaining ethical clearance and development of resources that will be used throughout the project. Thereafter it becomes possible to focus on sharing of information, as contact can be made with the target audience (F3/KDIF and F4/GOS) and their buy-in can be obtained as legitimacy is raised for the project (F7/COL).

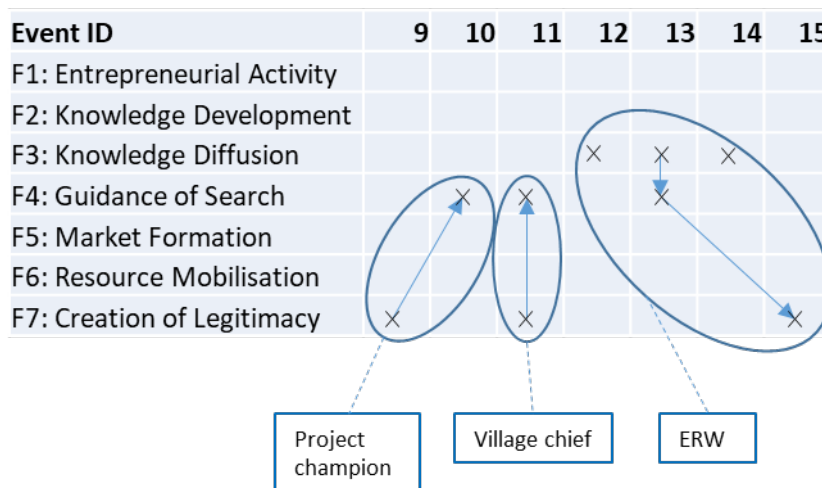
5.2.2. Phase 2: Obtaining Buy-in from Target Audience

During the first research visit, the team arrives late afternoon and enjoy dinner prepared by Mma C and her neighbours (F7/COL). During dinner, Mma C indicates that she is still unclear about the reason of the visit. She initially thinks the research team came to assist the community with their crop gardens and provide infrastructure for irrigation of the gardens. The team inform her that their reason for visiting has been explained in the documentation previously sent to her via email. They also cite the explanation of the ICT platform within the documents (F4/GOS). It was later realised that although Mma C has a cell phone, she rarely uses it and prefers face-to-face discussions.

According to local tradition, when outsiders visit the village of Mafarafara, the host must introduce the visitors to the chief of the village. As a result, Mma C takes the team to visit the chief and introduces them (F7/COL), the project and its desired outcomes (F4/GOS). This is seen to “open doors” to start the project in earnest by meeting with the community and building relationships with the ERW.

A meeting with the initial 25 ERW takes place in the community centre (F3/KDIF). The ICT platform project is introduced and explained and the purpose of the project to co-create is presented to the ERW (F4/GOS). Thereafter, the consent process begins and the ethics forms are read in Sepedi, the ERW’s native language. An opportunity for questions is presented which is followed by the signing of the consent forms by all the participants (F3/KDIF). The remainder of the time of the visit is mostly spent to get to know the ERW (F7/COL).

The events map for Phase 2 is shown in Figure 5-2 that indicates how this phase primarily involves two functions (F4/GOS and F7/COL) that play a crucial role to ensure the success of the project. Phase 2 is characterised by a high priority on forming trustworthy relationships through a series of engagements with community leaders and the target audience (F7/COL). Engagement events are used to explain project objectives and creating a shared vision (F4/GOS). This process is followed on three separate occasions, as indicated by the three circles in Figure 5-2, where engagement with different groups within the community takes place each time.



5.2.3. Phase 3: Prior Research and Installation

During the latter part of the first research visit, a meeting is scheduled where information of the women and their routines are gathered (F2/KDEV) and the research team visits and assess the potential site of installation of technology and solar panels (F2/KDEV). A member of the technical team visits Mafarafara village to assess the provided infrastructure of the community centre and determine what the best location for the ICT platform would be (F2/KDEV). In

addition, the person is tasked with identifying and mitigating any possible hindrances to the installation process. It is decided that the platform will be installed in a small room next to the main room of the community centre during the next research visit. The community centre has a thatched roof and therefore the solar panels powering the ICT platform need to be stationed upon a built steel frame outside the centre. The women are the only ones allowed to access the community centre, which makes it the ideal site to install the ICT platform. The installation takes place on the first day of the second research visit with the assistance of the ERW and two young men from the community (F6/RM). The information on the ICT platform consists of standard information that is commonly used in other sites of the DD initiative and information to address the information needs according to the ERW which they expressed during the first research visit (F2/KDEV).

The events map for this third phase is given in Figure 5-3. From this it is seen that once buy-in from the target audience is established as is discussed during the previous phase, it opens the door for the technology to be installed. The grouping of events focussing on knowledge development activities (F2/KDEV) as indicated by the circle in events map, collectively results in the installation of the technology (F6/RM), that in turn, through interaction with the ERW, leads to an improved understanding of the needs of the ERW (F2/KDEV).

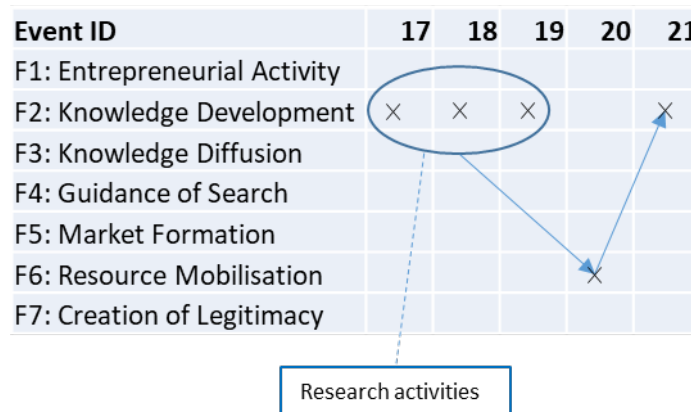


Figure 5-3 Events Map of Phase 3

5.2.4. Phase 4: Training and Usage

Once the platform is installed, the research team visits the chief in respect of cultural traditions (F7/COL) and to provide an update on the project (F4/GOS). Thereafter, a session with the participating ERW is held and the project is explained again to new participants (F3/KDIF). During these discussions, the team emphasizes the fact that any of the ERW of the village is welcome to participate in the project to value inclusivity (F4/GOS). During these discussions

the agreements reached during the first research visit are revisited. A break is taken around lunch time and the research team share some biscuits and juice that they brought with for the day.

Training is scheduled to start on the third day of the second research visit, but upon arrival it is seen that some of the ERW are not present. The reason for this is that it is the collection day of the monthly pension grant that some of the ERW receive. Training carries on however (F3/KDIF) and is continued on the fourth day to provide an opportunity for those who missed the first day of training to catch up. During training, interviews are held with some of the ERW to gain insight into their livelihoods and informational needs, while others received training and started to work on the ICT platform (F3/KDIF). From the various interviews it is gathered that the biggest problem that the ERW face, is the lack of irrigation for their crop fields. It is also realised that although the ICT platform provides important agricultural information, the effect thereof would be insufficient if proper irrigation is not available. Mma C is encouraged to identify someone from the target community whom she can mentor and fulfil the role of her assistant. Two young men who helped with the installation of the platform and the solar panel frame are identified and they receive training (F3/KDIF), enabling them to help by providing technical and maintenance assistance (F6/RM). During this visit, the font size of the ICT platform is enlarged to accommodate poor eyesight that some of the ERW suffer of (F3/KDIF).

The events map for Phase 4 is illustrated in Figure 5-4. The first grouping indicates the emphasis on advocacy activities that in the process communicate inclusivity to convince the target audience to take part in the project (F4/GOS and F7/COL). This is followed by the second grouping of training and engagement activities where the project team also finds out more about the target audience and their needs (F3/KDIF).

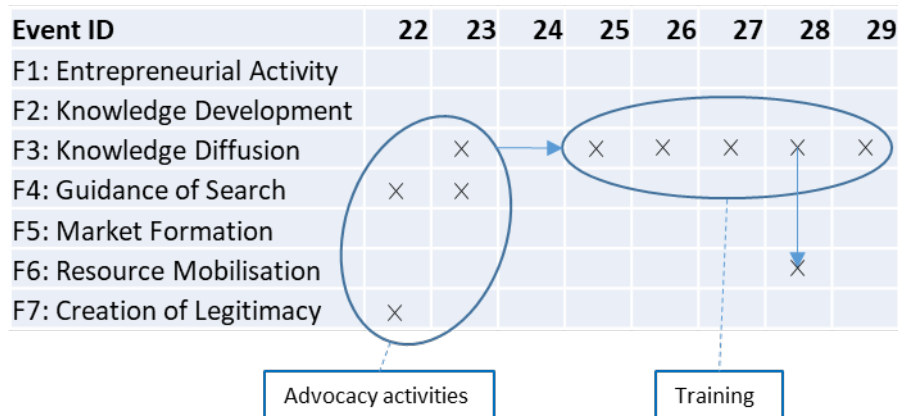


Figure 5-4 Events Map of Phase 4

5.2.5. Phase 5: Project Shaping and Adjustments

Three months after the initial visit, during which the ICT platform was installed, the third research visit is conducted, with the primary purpose of gathering feedback from the target audience of their experiences using the platform. In the beginning of this visit, group discussions are held, where feedback and suggestions are gathered related to the ICT platform (F2/KDEV). From these discussions it is gathered that the ERW enjoy using the platform and they state that they have learned valuable things (F4/GOS and F7/COL). They take turns to use the platform and while they wait, they attend to their sewing activities. From observations made by the research team, it is seen that there exists interest among the ERW to use the ICT platform. The ERW state that they are still waiting for promised upgrades in their native language (Sepedi). This request is attended to during the next technical visit between the third and fourth research visits. During these discussions, the concepts of ownership, personal responsibility and empowerment are advocated for and highlighted (F4/GOS).

The team brings food to share with the participants of the project which they gladly receive and express their appreciation (F7/COL).

It is also gathered that the ERW are appreciative of the training offered to the two young men during the second research visit, however they express their uncertainty of the roles of the two young men. Even though there were never any mention of employment or remuneration for the men, a hope and desire for this existed among the community. Training activities are held and during these activities a login for each of ERW is created so that their personal information can be uploaded to their own files (F3/KDIF).

The research team seeks to help the community by attempting to convince the agricultural office in a neighbouring town, which forms part of the Department of Rural Development and Land Reform (DRDLR), that the Mafarafara community need help with irrigation, but the attempt is not successful (F4/GOS). The reason for this is not clear, however, the research team plan to continue this endeavour during the next research visit.

A technical visit is conducted during which the solar panels powering the ICT platform is upgraded to increase the battery life of the platform (F6/RM). The information base of the platform is also expanded as the new information is added in accordance to the request of the ERW during the second and third research visit (F2/KDEV). The information contains knowledge related to disease control in agriculture and health ailments, along with treatment procedures of the ailments which have been previously affecting the target audience.

The events map of this phase is shown in Figure 5-5. The encircled events show how, once the technology is implemented and is being used by the target audience, there is an emphasis to obtain feedback (F2/KDEV) and thereafter adjust the system to suit the needs of the target audience. Positive feedback from the target audience also raises advocacy about the project (F7/COL). Since the usage of the technology may have not yet become a part of the daily routines of the target audience, the feedback and subsequent adjustment of the system is an integral part of the project that encourages the target audience to continue using the technology. The continued usage develops the skillset of the target audience and empowers them.

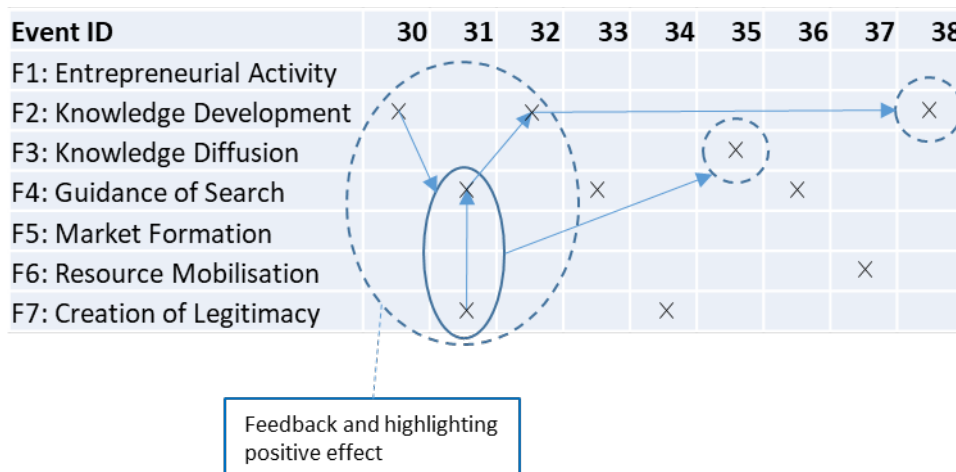


Figure 5-5 Events Map of Phase 5

5.2.6. Phase 6: Monitoring Visits

Phase 6.1: Research visit 4

The purpose of the fourth research visit is to continue to gain feedback from the ERW regarding their usage of the ICT platform and to gather insight into their daily way of living. Furthermore, high on the agenda would be a second visit to the agricultural offices of the DRDLR in a neighbouring town to follow up on the initial inquiry for assistance of the ERW during the third research visit.

During this visit the research team consists of two people, of which one takes part for the first time. When the team arrives, Mma C welcomes them and the research team hands over porridge meals and vegetables that they brought along for the ERW (F6/RM). The ERW express their gratitude towards the team members. They decide to ration the food so that it can be eaten over two days. The second day is started by visiting the residence of the chief (F7/COL). Two funerals in neighbouring communities stall the planned activities of the day, since most members of the ERW attended the funerals.

Interviews with 11 ERW are held who use the ICT platform on a regular basis (F2/KDEV) and they express their desire towards the research team to add specific information related to health to help them with some of their ailments and information on improving their agricultural activities. From the interviews it becomes clear that their experience of using the platform is overwhelmingly positive. They felt proud of their achievements thus far of logging in and being able to work on the platform (F7/COL). Engagement with other members of the village reveals that the rest of the community also approve of the whole project because of seeing how the ERW benefit from it (F7/COL).

The agricultural offices of the DRDLR is visited again. The plea for assistance towards the offices is to advocate for help from the DRDLR for irrigation of the gardens of the ERW, since it is their primary source of nutrition. The team convinces two officials to come to Mafarafara. Upon arrival, the officials realise that the request for assistance is legitimate and as a result commit to engage with the ERW and to assist them (F6/RM).

Phase 6.2: Research visit 5

Upon arrival of the fifth visit, the ERW are waiting for the team at the community centre. The ERW are happy to see the team, but they also express their desire for the team to have visited earlier. They do however admit that this would not have been possible, because of a traditional initiation school held by Mma C and related festivities within the community, in which the ERW took part. The school is very important to the community and people from other provinces as far as Gauteng came to Mafarafara to attend the school. The rest of the afternoon is spent together discussing project activities since the previous visit by the research team (F3/KDIF). It is also mentioned that some of the ERW that initially took part in the project, unfortunately lost interest. The ERW admit that the week before the research team arrived was the first week in some time that they actively took part in the activities, as their attention was with the initiation school and related activities.

Excluding the time that was allocated to the initiation school and subsequent activities, the usage of the ICT platform seems to form part of the daily routine of the ERW, as is evident from the accounts given by different women explaining their daily usage of the platform (F3/KDIF). The women explain their daily routine: They come together in the morning at the community centre and start off by praying. Thereafter the machine (ICT platform) is switched on and the platform and room housing, it is cleaned. Then some women log in, check their personal files and play the educational games that are installed on the platform, while others go work in the community garden and others sew. They take turns to work on the platform and when one is tired, others get a chance to work on it. They also mention that they assist one another during the processes. Some of the older women have trouble entering their names and are assisted by others (F3/KDIF). The two young men still assist the ERW by switching the platform on and taking care of technical tasks (F3/KDIF).

Six months after the fifth research visit in August 2014 and two months before the sixth research visit to take place during April 2015, the ICT platform is removed in February 2015 during a technical visit. This done to perform maintenance on the platform and to install updates.

New information is added onto the platform, consisting of health (remedies to help with old age ailments such as arthritis, asthma, cramps and other ailments experienced by children),

agriculture (crops that can be grown and suitable conditions for growth, diseases commonly experienced among crops, common pestilences and suitable insecticides, indigenous plants and their benefits for use and livestock), lighting and thunderstorms (which is a common occurrence at Mafarafara), clothing patterns, ideas for crafts, a basic accounting program that the ERW can use to calculate their business profits or losses, educational stories and information about the funders of the project; governmental and non-governmental (F2/KDEV).

Infrastructural changes are planned and finalized to include a printing facility (F6/RM), which will greatly benefit the ERW and their children, as well as the greater community of Mafarafara, as well as chairs for the ERW to sit on while working on the platform so that they do not tire because of continued standing while working (F6/RM).

The events map for Phase 6 is given in in Figure 5-6. The focus of the phase is primarily to obtain further feedback in addition to Phase 5. Observations from the events show that further buy-in is obtained and a sense of pride to be part of the project is raised among the target audience. This is indicated by the first and second encircling in Figure 5-6. In addition, the assistance offered by the project team to the target audience in the form of irrigation (F6/RM) also helps to drive advocacy (F7/COL). It appears that the technology has become embedded in the lives of the target audience (F3/KDIF).

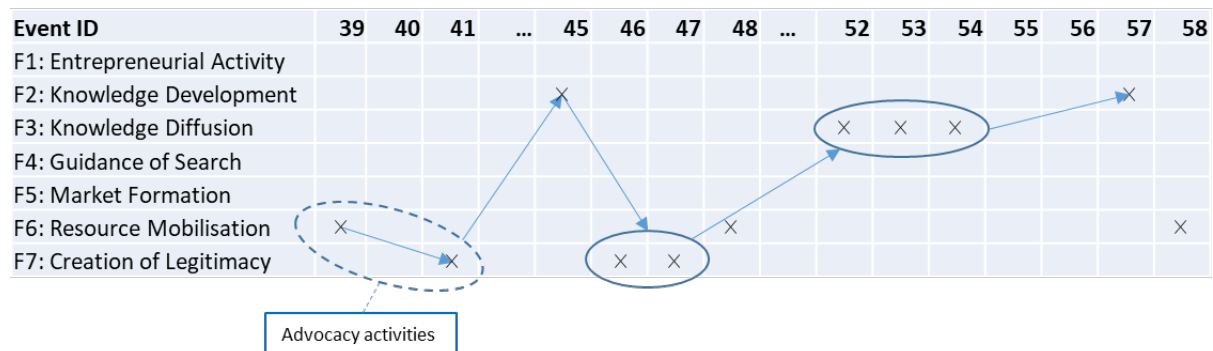


Figure 5-6 Events map of Phase 6

5.2.7. Phase 7: Reinstall Technology

As mentioned within Phase 6, the ICT platform is removed for two months before a sixth research visit is done with the primary focus to reinstall the updated ICT platform. The ERW and rest of the Mafarafara community warmly welcome the research team upon their arrival in the afternoon. The remainder of the day is spent meeting new people, gathering an understanding of the diffusion of the project among the community (F2/KDEV) and continuing

to build relationships by finding out more about the village and the lives of the people (F7/COL).

The ERW once again mention their desire for the composition of the research team to be constant and ask if the personnel can be fixed from now on until the completion of the project.

Twelve one-on-one interviews are held with participating ERW to collect data about the experience of the ERW related to the whole project and using the ICT platform (F2/KDEV). A brief overview of the informed consent forms previously signed (see first and second research visits) is given again as part of the interviews. From these interviews it is gathered that a core group of the ERW regularly visit the community centre to work on the ICT platform and this group has remained consistent throughout the duration of the project. It is also stated that there exists a collective belief among one another that they are part of a group and they feel empowered as a result being able to give advice, share knowledge and help one another (F7/COL).

The ICT platform with updated information is reinstalled (F6/RM). The ERW all require renewed training to be able to work on the platform (F3/KDIF). The removal of the platform had a greater social impact than what was previously anticipated. The women tell the research team that they were bored and felt that they did not know what to do with their time.

Thereafter, a meeting is held with the ERW to discuss the printing facility. It is stated that the women will have to take responsibility of the printer and buy the necessary supplies (cartridges and paper) when the stock is diminished. As a result, a pricing policy is determined, and someone is identified to take responsibility by collecting and handling the money when the printer is used (F6/RM).

The events map for Phase 7 is given in Figure 5-7, and it shows that two functions are important during this phase (i.e., F6/RM and F3/KDIF). Concluding from this phase, it shows that when the ICT platform is reinstalled (F6/RM), the target audience require renewed training (F3/KDIF). This seems to be a simplified combination of Phase 3 (Installation of technology) and Phase 4 (Training and usage).

Event ID	59	60	61	62	63	64
F1: Entrepreneurial Activity						
F2: Knowledge Development		×	×			
F3: Knowledge Diffusion						×
F4: Guidance of Search						
F5: Market Formation						
F6: Resource Mobilisation					×	
F7: Creation of Legitimacy		×		×		

Figure 5-7 Events Map of Phase 7

5.2.8. Phase 8: Unplanned Stalling of Project

A seventh research visit is conducted after the research team is informed that the community centre where the ICT platform is installed, was damaged due to a storm. The facility cannot be used anymore, since the thatched roof of the centre caved in. Further interviews are held to get an idea of the experience of the women after the platform cannot be used anymore (F2/KDEV). They collectively state that they miss the platform a lot. One of the women states her desire that the platform remain at their community and not be taken elsewhere.

Under the leadership of Mma C, the women have started to actively gather support for the building of a new multi-purpose brick building (F6/RM). The ERW express their willingness to take responsibility for maintenance of the platform, should the project start again (F6/RM).

As there is no other facility within the village where the platform can be relocated to, the project is put on hold while the ERW gather support for building a new centre. This is unfortunately a slow process, since their plan is to start building the structure as resources become available.

During November 2018, a technical visit is conducted and a new community centre has been built that contains a corrugated iron-roof (F6/RM). This would be a suitable location to implement an updated ICT platform anew. At the time of the conclusion of these observations, Mma C is not available and the project is halted.

At the time of writing the conclusion of the outcomes of the phases, the project team has recently secured a more advanced and improved DD for the target audience, and they are using the new ICT Platform regularly.

5.3. Case Conclusion

As mentioned in Section 4.1.4, it is possible to use the insights and events maps to visually show through CLDs how the different functions develop over the duration of the case. The causal chains and causal loops present in each phase are indicated with red arrows in each CLD. This process is started by reflecting on the causation chain of Phase 1 in Figure 5-8. During the first phase in the project, the focus of the project team is on developing the technological infrastructure, identifying a suitable target community and testing the developed technical infrastructure (F2/KDEV), which leads to diffusing and sharing project information with the target audience (F3/KDIF) in order to develop an enhanced belief in the project goals (F4/GOS). These efforts finally lead to a willingness from the target audience's side to partake in the project – therefore making themselves active actors throughout the project (F1/EA).

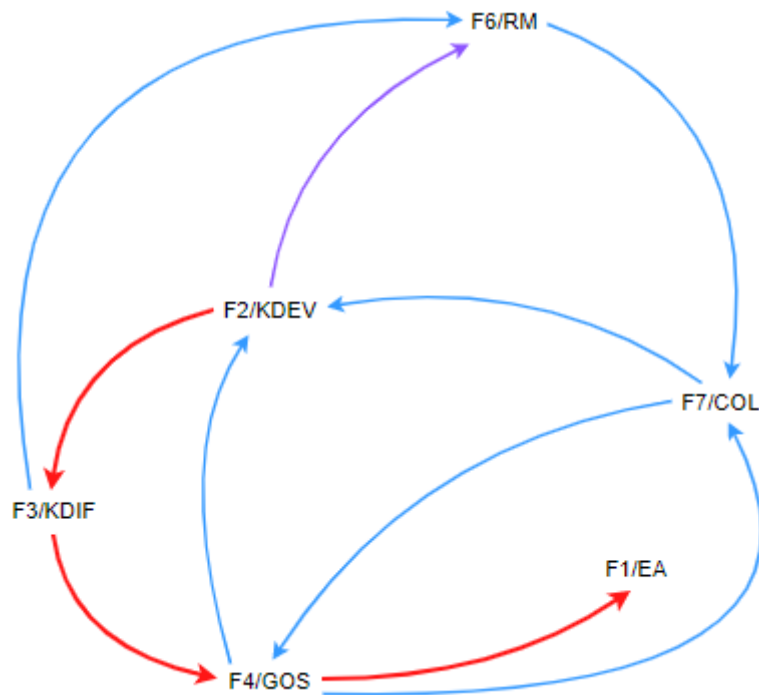


Figure 5-8 Phase 1 - Functional Dynamic for Pre-engagement and Preparation

Phase 2 begins with the active role of the community (F1/EA) in building up trustworthy relationships through a series of engagements with community leaders and the target audience (F7/COL). This reinforces the beliefs in the project goals (F4/GOS), forming the first reinforcing feedback loop. This means that a lesson can be drawn that, once the support from community leaders is achieved, a sustaining mechanism is produced between the goals, the active role of the community and the support from the community leaders (See Figure 5-9).

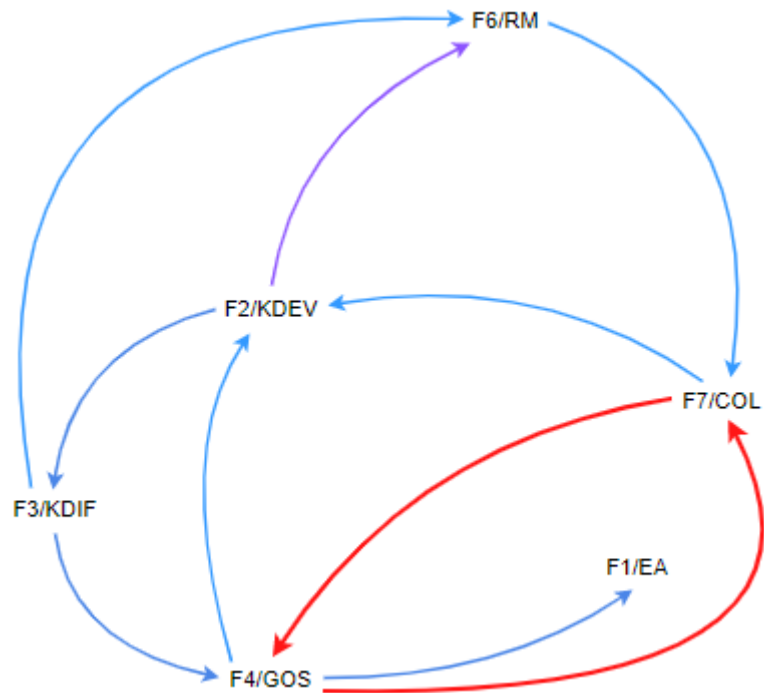


Figure 5-9 Phase 2 - Functional Dynamic of Obtaining Buy-in from Target Audience

In Phase 3, it is observed that once a trustworthy relationship has been built, efforts in identifying the information needs from the target audience (F2/KDEV) lead to mobilising resources (F6/RM) to set up the required technology infrastructure – again reinforcing project legitimacy (F7/COL), forming the second reinforcing feedback loop in Figure 5-3. The lesson to be drawn here is that this second feedback loop indicates the importance of adequately identifying user needs before any resource is allocated to keep building up project legitimacy.

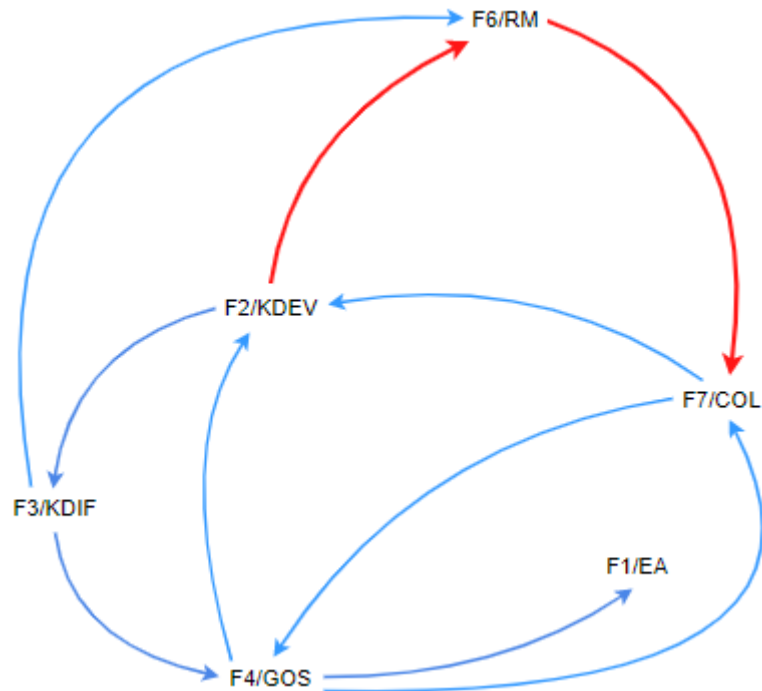


Figure 5-10 Phase 3 - Functional Dynamic of Prior Research and Installation

As the project evolves, user training began in Phase 4 (F3/KDIF), creating the role of project advocates throughout the community, but also helping out in better and more efficient resource allocation – including the active role of community members in maintenance and other technical activities (F6/RM) (See Figure 5-11). It is worth noting that besides the formation of the third reinforcing feedback loop, all system functions are part of at least one feedback loop, showing up the intricate relationships forming in the project. It is also important to note that this notation allows for insight to be drawn that if a function fails to achieve its purpose, it sets out a chain reaction process, affecting several others at the point of possibly jeopardising the project as a whole. This helps to overcome only identifying the positive reinforcing behaviours in such a project. Acknowledgement is given to function failure and consensus for the project.

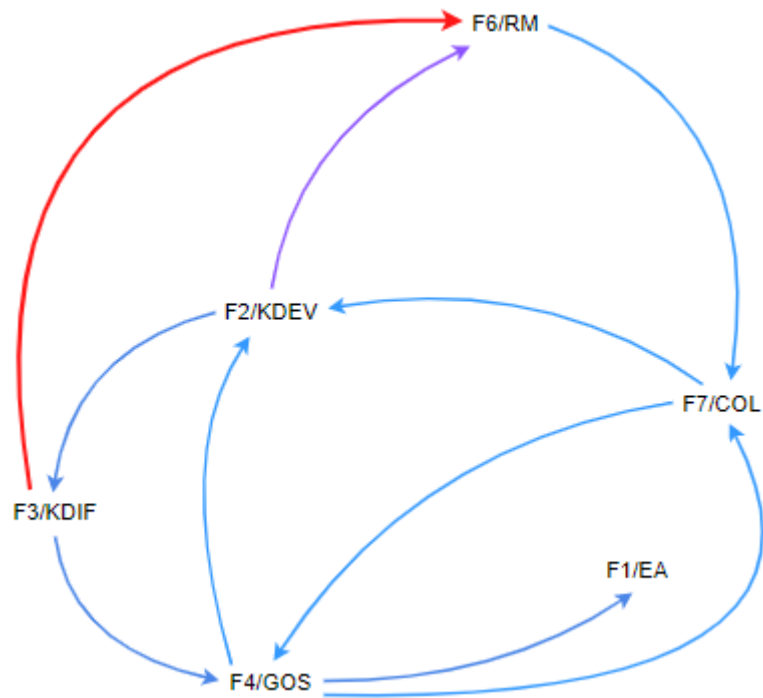


Figure 5-11 Phase 4 – Functional Dynamic of Training and Usage

In Phase 5, as the target audience recognises the positive impact of the usage of the ICT platform, so does their belief in the ongoing potential of the project (F4/GOS), resulting in requests by the target audience to increase the functionality of the platform by adding new information (F2/KDEV). After the platform is updated, usage and interest on the platform grow (F3/KDIF) (Figure 5-12).

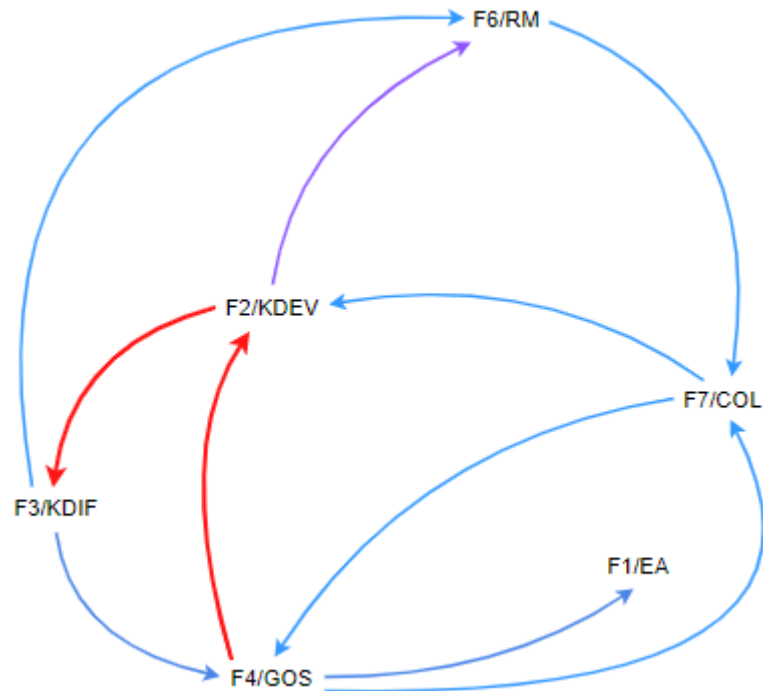


Figure 5-12 Phase 5 – Functional Dynamic of Project Shaping and Adjustments

After Phase 5, it is possible to note that all reinforcing mechanisms lead to increasing - somewhat organically – the interaction among system functions. In other words, the community and the platform are already intertwined and interaction between functions happened naturally since the platform usage became part of the daily routine. Therefore, in Phase 6, the main aim is to conduct monitoring visits for user feedback and minor platform adjustments. This dynamic is shown in Figure 5-13 and highlights the interaction between F3/KDIF and F4/GOS.

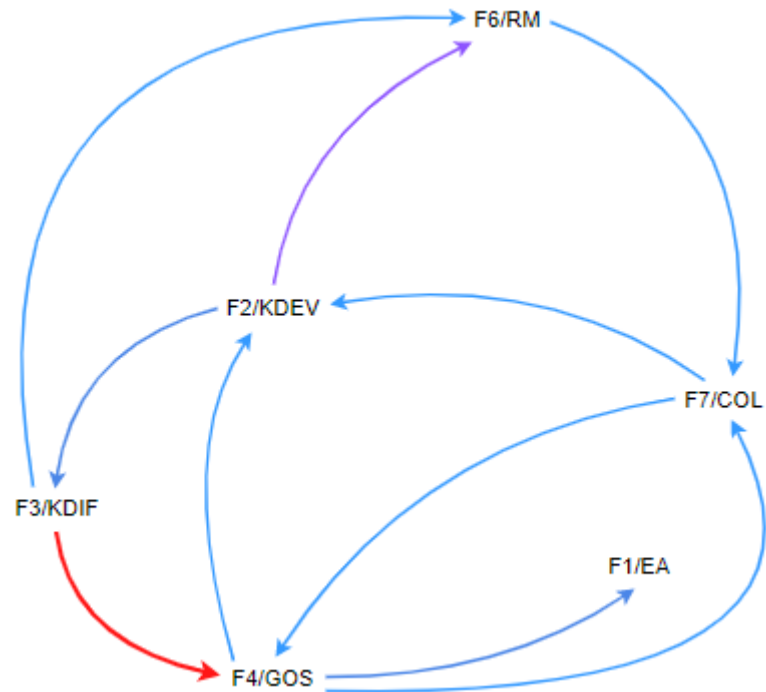


Figure 5-13 Phase 6 – Functional Dynamic of Monitoring Visits

Finally, in Phase 7, user feedback and the need for platform updates (F2/KDEV) result in removal of the platform and posterior reinstallation (F6/RM). Afterwards, some re-training was required, but as Figure 5-13 shows, new efforts are mostly minor. Figure 5-14 shows the final CLD for the Mafarafara case.

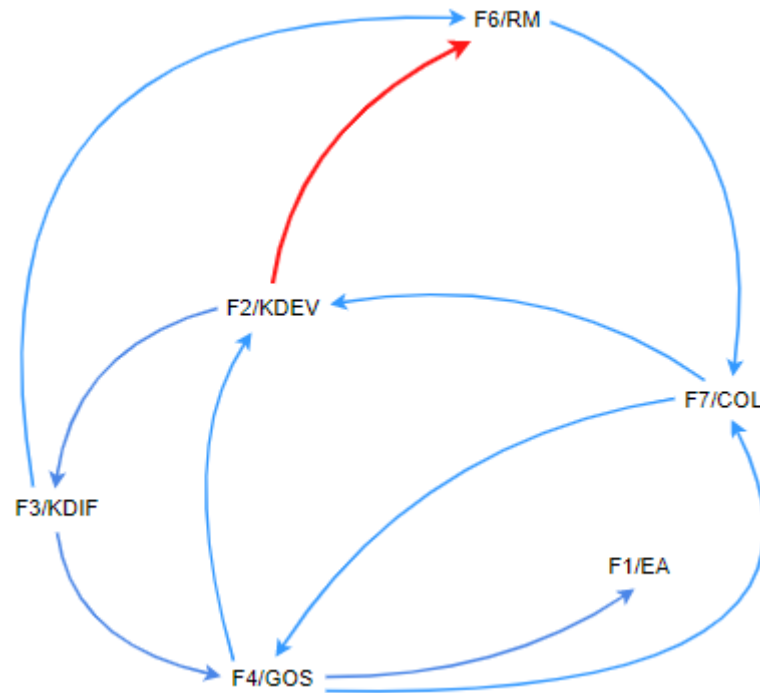


Figure 5-14 Phase 7 – Functional Dynamic of Reinstalling the Technology

In addition to the functional dynamics, it is possible to cumulatively map the fulfilment of functions across the 74 Event IDs to get the trend pattern of the case and the result of this is given in Figure 5-15. The pie charts show which functions are focused on most during each phase of the project. By doing this analysis, it shows that the focus on activities shifted from the development of knowledge (F2/KDEV) and guidance of search (F4/GOS) (Phases 1–3) to knowledge diffusion (F3/KDIF) during the uptake of the technology (Phase 4), with a bigger focus on resource mobilization (F6/RM) and market formulation towards the later phases (Phases 5–8).

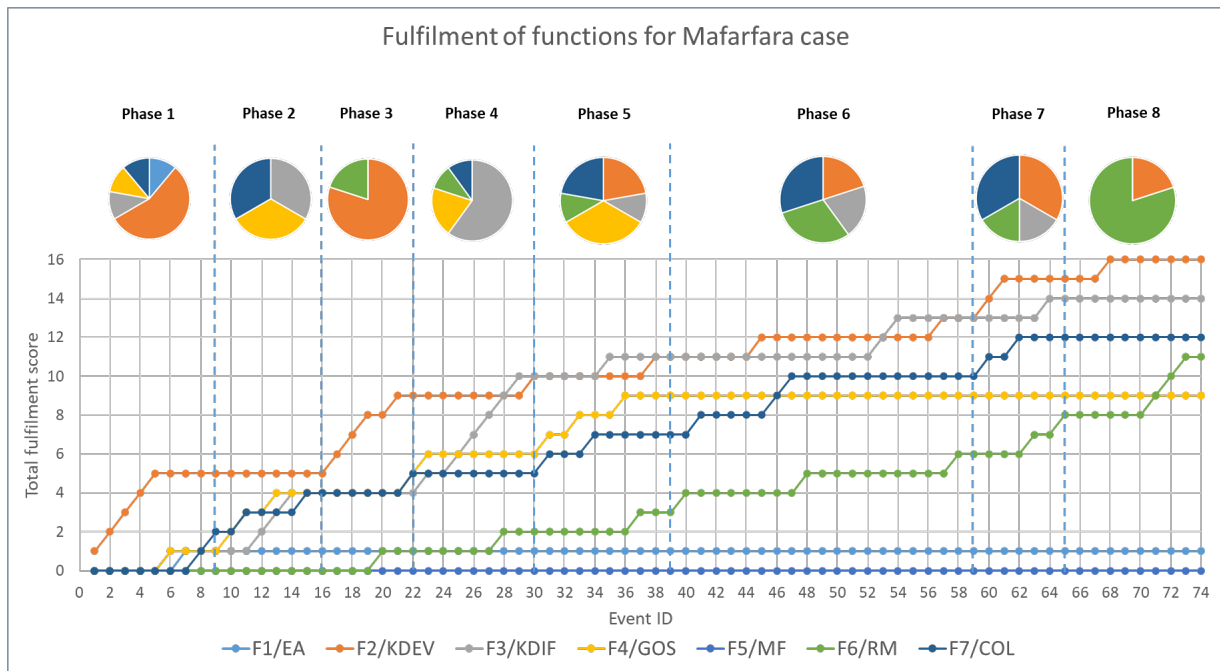


Figure 5-15 Trend Pattern of Mafarara Case

5.4. Chapter Summary

In this chapter, the Mafarara case (the first of three case studies in this document) is analysed according to first four steps of the EHA method explained in Section 2.1 and 4.1, to identify key events in the development and evolution of the ICT4D Mafarara project. Section 5.1 provides the background and purpose of the project carried out. Within Section 5.2, the data collection and database construction for the case are discussed, the events are mapped to the different system functions, and eight phases are identified. The interaction patterns are also identified and given in the form of events maps for each phase. Conclusions are made and the overall CLD of the case is given in Section 5.3 in addition to the trend pattern of the case.

Chapter 6

Case B: ICT4RED

In this chapter, the second of three case studies is analysed using the analytical approach discussed in Chapter 4. An introduction of the case study is provided in Section 6.1. Within Section 6.2 the events of the case are related to the functions they fulfil. The case is then divided into five phases and for each phase an events map is given to identify the causal chains and feedback loops of the specific phase. In Section 6.3, the causal chains and feedback loops are used to construct a CLD of the case that illustrate the narrative of the core dynamics identified as the case evolved over time.

6.1. Introduction to ICT4RED Case Study

The Information Communication and Technology for Rural Educational Development (ICT4RED) initiative is a large-scale research, development and implementation pilot project that spans over three years. With this initiative, the implementation of tablets to aid teaching within 26 deep rural schools is tested. The schools wherein the initiative is implemented, form part of the Nciba Circuit of the Cofimvaba school district in the Eastern Cape Province of South Africa, the poorest province in the country. This area is seen as a resource-constrained environment, since it is characterised by limited economic opportunities, low income and a high unemployment rate among the residents, a diminishing number of economically active people in contrast to an increasing number of youth going to schools. (Herselman and Botha, 2014)

Within the South African educational system, each of the provinces is divided into districts. In turn, the districts are subdivided into circuits. A district office is responsible for managing the schools within the circuit. Interaction takes place between all the different levels of stakeholders in the educational system. This means that interaction takes place between the district officials, governmental officials and the relevant government departments such as the Department of Basic Education and the Department of Higher Education & Training. The ICT4RED initiative is implemented within three different aged school groups: Senior secondary schools (Grades 10 to 12), junior secondary schools (Grades 7-9) and primary schools (Grades R to 6). (Herselman and Botha, 2014)

The ICT4RED initiative forms part of the Technology for Rural Education Development (TECH4RED) research program which “aims to contribute to the improvement of rural education via technology-led innovation” (Herselman and Botha, 2014). The TECH4RED research program was started by the Department of Science and Technology (at the time of writing this report, it was known as the Department of Science and Innovation) in collaboration with various other governmental departments (Department of Basic Education, Eastern Cape Department of Education, Department of Rural Development and Land Reform) and the Council for Scientific and Industrial Research (CSIR) to “enable positive contributions at all levels and spheres of influence in the school system” (Herselman and Botha, 2014). The Department of Science and Technology primarily funded the project throughout its duration, while the Department of Rural Development and Land Reform funded the infrastructure (physical and technological) that was implemented and installed. The CSIR was tasked to head the initiative.

The primary purpose of the ICT4RED initiative is to identify if and how the implementation of suitable technology, referring to technological devices and supporting technological infrastructure, leads to improved quality of teaching and learning in rural environments (CSIR Meraka and Benita Williams Evaluation Consultants, 2015). The focus of the initiative is to incorporate the usage of technology within teaching and learning methods, instead of focussing on improving technological literacy. As a result, the initiative makes use of mobile technology (tablets) and distributes it to the various schools to be used by teachers and learners to support teaching and learning. Supporting technological infrastructure is also installed at the schools to aid the usage of the mobile technology. The desired outcome of the ICT4RED initiative is to improve engagement between teachers and learners and inform future policy in the context of technology and education within South Africa, while ensuring that the implemented changes last beyond the initiative as a result of proper integration of the technology within educational processes that are already present. (Herselman and Botha, 2014; CSIR Meraka and Benita Williams Evaluation Consultants, 2015)

Before the start of the initiative, an opportunity is seen to use the insights gained during this initiative to develop artefacts such as models, frameworks, guidelines or tools that can be used to guide the design and implementation of similar initiatives in the future. As a result, various such artefacts are developed in parallel with the implementation of the initiative within the schools, resulting in the development of the primary artefactual output: a contextual framework

known as the ICT4RED Implementation Framework that consists of evidence based-policy outputs to be used by provincial and national governments for similar future initiatives. (Herselman and Botha, 2014)

The initial concept of the ICT4RED initiative is to distribute tablets to the various schools to use as e-books to counter the logistical problems of distribution of paper-based textbooks that South African schools often face. This however, only became the starting point. Various educational content is uploaded onto the tablets to suit the needs of the target audience. For example, tablets to be used by teachers received different content to the tablets that are to be used by learners. As the initiative evolves, the technology is further utilised to enhance teaching and learning: Videos are created for educational purposes and shared within classes, new content is downloaded from a central server and online assessment is used. (Herselman and Botha, 2014)

Throughout each of the initiative's stages, an ICT champion is assigned to each school. As ICT champions within the schools, the roles of young people are to support teachers, and later to serve on the internal ICT committees (established by the schools themselves after the initiative is implemented in their schools), with the management and maintenance of the ICT infrastructure. (Herselman and Botha, 2014)

6.2. Data Analysis

For this initiative, none of the events had specific dates and times ascribed to them. However, for the different stages, a step-by-step diagram of the main processes of the stage is given with the sub-processes discussed in the text. An example of such a diagram is given in Figure 6-1. The sorting of the events in chronological order is primarily done according to these figures. However, the discussion of the stages in the text of the book further aids the process to give a clear picture of the sequence in which events occurred.

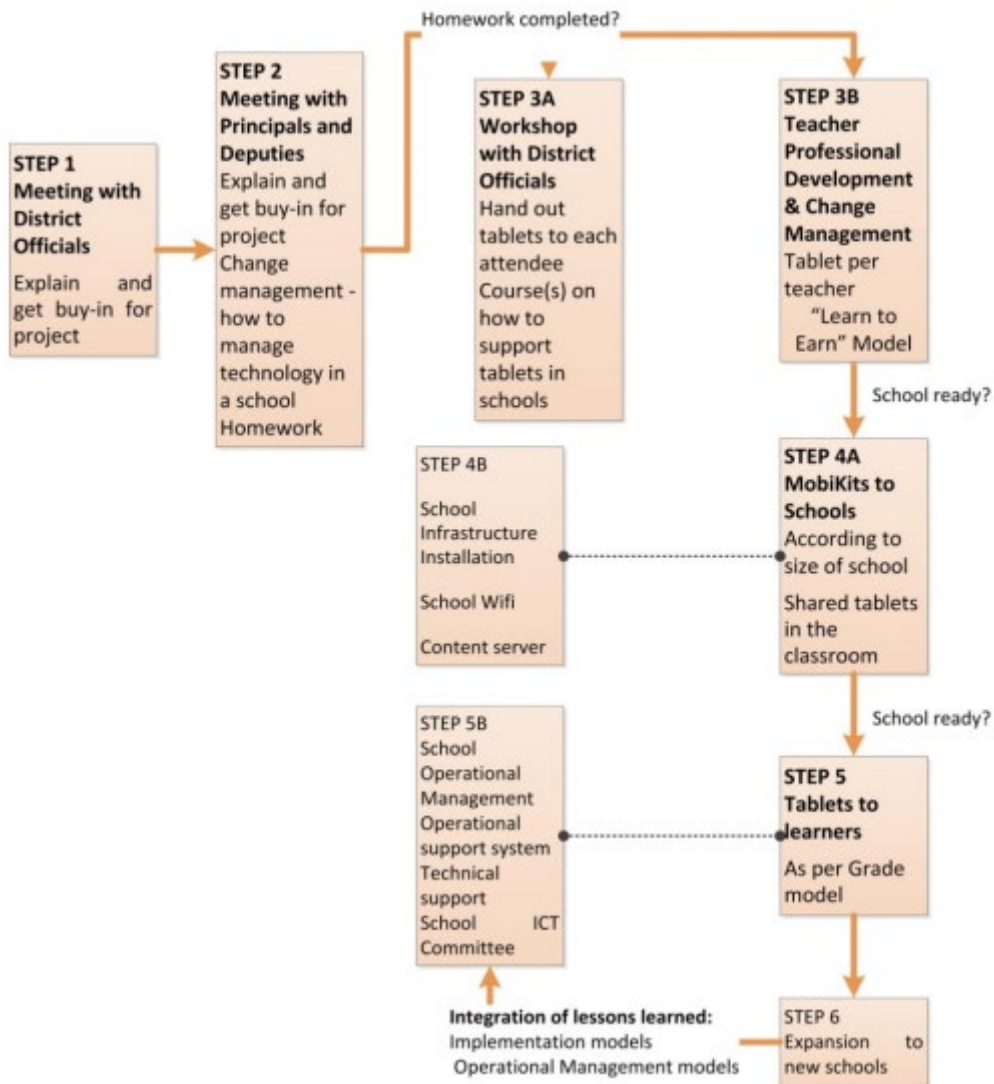


Figure 6-1 Step-by-step Process Diagram for Stage 2 (Herselman and Botha, 2014)

In total, 79 events are identified in the case and an event ID is ascribed to each event. For each event it is considered if the event led to the fulfilment of one or more functions in accordance to the explanation set out in Section 4.1.3. The result of this is given in Table 11 in Appendix A.

Distinct phases within the case are identified according to the process explained in Section 4.1.4. In total, five phases are identified:

- Phase 1: Research and preparation
- Phase 2: Obtaining buy-in from target audience
- Phase 3: Preparation and training
- Phase 4: Phase 4: Implementation, usage and feedback

- Phase 5: Project disengagement and handover

As explained in Section 4.1.4, some cases consist of various stages and phases. This particular initiative consists of three stages (Stage 1 to Stage 3), where the initiative is implemented among different target audience groups each time. Within Stage 1, the initiative is implemented within the target audience for the first time as the initiative starts at one secondary school as a pilot for the rest of the intervention. The objective of this stage is to use the results and outcomes to guide the iteration process of the design of initiative in the next stage. At the conclusion of the stage, feedback is gathered, outcomes and findings are synthesised, and iterations are made to the implementation processes to improve the design of the initiative. Stage 2 uses what is learned during Stage 1 and iterates the design of the initiative. This stage is the first attempt to implement the initiative within various schools and contexts. As a result, the initiative is implemented within 11 additional schools, comprising of primary and secondary schools. Once again, feedback is gathered from the target audience and the necessary iterations are made to the design of the initiative. The initiative is implemented in more schools in Stage 3 as 14 new schools take part. These schools include a selection of secondary, primary and junior schools.

The involvement of the different schools is illustrated in Figure 6-2. As a result of this design of the initiative, Stages 1-3 follow similar steps to implement the initiative among the target audience. Small differences occur as a result of iterations made based on the findings of the preceding stages. This means that these stages consist of similar events and consequently similar sequences of function fulfilment.

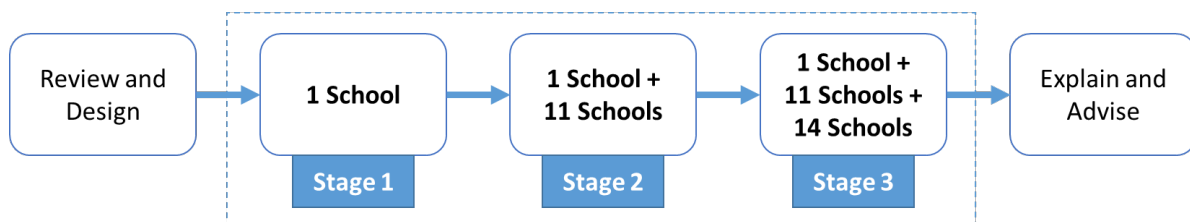


Figure 6-2 School Involvement during Project Stages [Adapted from (Herselman and Botha, 2014)]

Stages 1-3 follow similar patterns of events as a result of the iterative nature of the initiative. Within the various stages of the case, Phases 2-4 repeat itself when the initiative is expanded to new schools. At the start of the case, the *Research and preparation phase* occurs before the initiative is expanded to the target audience. When the initiative is implemented within the first

school during Stage 1, the *Obtaining buy-in from target audience, Preparation and training phase, and Implementation, usage and feedback* occur. This sequence of phases is repeated during Stage 2 and again during Stage 3, before the *Project disengagement and handover phase* occurs for the first time during the latter part of Stage 3 and for the duration of Stage 4. This makes the narrative story of this case unique. The narrative story is constructed according to the different phases. However, within Phases 2-4, the three different accounts as a result of the three different stages are combined to construct a narrative story that uses the insights gained from the different stages. The presence of stages within the different phases is illustrated in Figure 6-3.

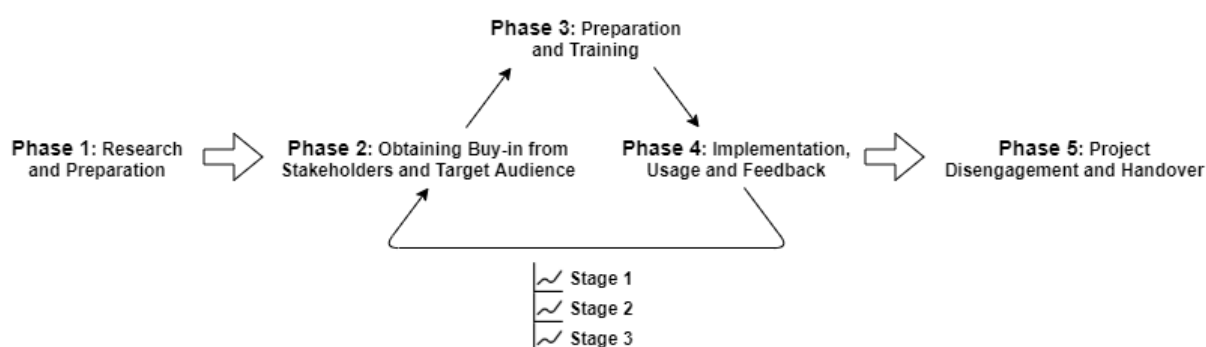


Figure 6-3 Sequential development of phases in ICT4RED case

Most of the planning and scoping work of the initiative takes place during Phase 1, just before Stage 1 starts. New planning and scoping activities also take place at the start of Stage 2 and Stage 3 as the lessons learnt from the previous stages are synthesised and integrated to form part of the new stage. (Herselman and Botha, 2014)

6.2.1. Phase 1: Research and preparation

The initiative is started as ethical approval is obtained from the ethical committee of the applicable research institution and governmental authority to carry out the research (F2/KDEV). Once this is completed, research is started by conducting a thorough literature review to identify similar cases where technology was implemented to enhance education. The aim of the review is to gather an understanding of what were success factors in previous cases and what did not work so that it can be incorporated within the ICT4RED initiative. Further research is conducted to see if useful models and frameworks exist that are relevant for the initiative and development of the artefacts (F2/KDEV). From this research a conceptual framework is identified within literature that has been previously used for ICT initiatives within education that consists of six components that are adapted to suite the specific environment of the ICT4RED initiative that leads to the development of an initial model that guides the

implementation and operationalisation of the initiative (F2/KDEV). Further consultation with educational experts and role players leads to the addition of more components to ultimately make up the following components of the model: Initiative Management, Monitoring and Evaluation, Technology, Content, Operations Management, Pedagogy, Change Management and Research (F2/KDEV). For each component of the model, a champion is assigned from the initial research team that takes responsibility for the specific component. The champions make up the core ICT4RED research team (F6/RM) and are tasked to draw up the important processes to be fulfilled for each component. The champions come together on a weekly basis to track their progress and get feedback for each component and investigate areas of integration among the components (F2/KDEV). The model is finalised and it is the first artefact that is designed during the initiative (F2/KDEV).

A technology scan is conducted to determine whether tablets or e-readers should be used during the initiative (F2/KDEV). The advantages and disadvantages of each option are given to the Department of Basic Education and they decide it is best to use tablets. As a result, low-cost seven-inch tablets are acquired (F6/RM).

The events map for Phase 1 is given in Figure 6-4. It can be seen that this phase involves two functions with the emphasis on F2/KDEV (indicated by the two encircled groupings), where a lot of research was done to support programme setup and the selection of appropriate mobilisation resources (F6/RM).

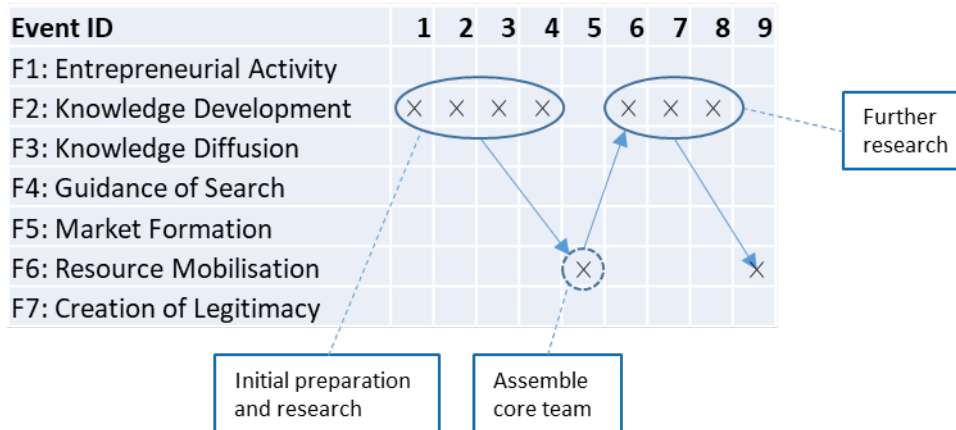


Figure 6-4 Events Map of Phase 1

6.2.2. Phase 2: Obtaining Buy-in from Target Audience

The first stage of this phase is started as a pilot project (F2/KDEV) begins to implement the initiative within one school, providing the first opportunity for the target audience to partake in the initiative (F1/EA).

The initiative is explained to governmental officials from the Cofimvaba district and district officials of the Nciba Circuit who are responsible for the area where the school is situated (F4/GOS). This is done to obtain their support and cooperation during the initiative (F7/COL).

Members of the ICT4RED team meet with the chief of the community where the school is situated. The project is explained to him (F4/GOS and F7/COL) and he gives the team his blessing and support for the project. Thereafter, the ICT4RED team meets the principal, deputy and the governing body of the school to explain the initiative to them and gather their support and cooperation (F4/GOS and F7/COL). These actors buy into the initiative and are willing to work together throughout the initiative.

Upon establishing buy-in from the necessary actors, an ICT champion is identified by the CSIR and assigned to the school to do novel tasks and support teachers where necessary once the school starts to implement the usage of technology within their teachings later on in the stage (F6/RM). It is decided that the ICT champion will receive training with the school leaders. The events for Stage 1 are shown in the events map in Figure 6-5.

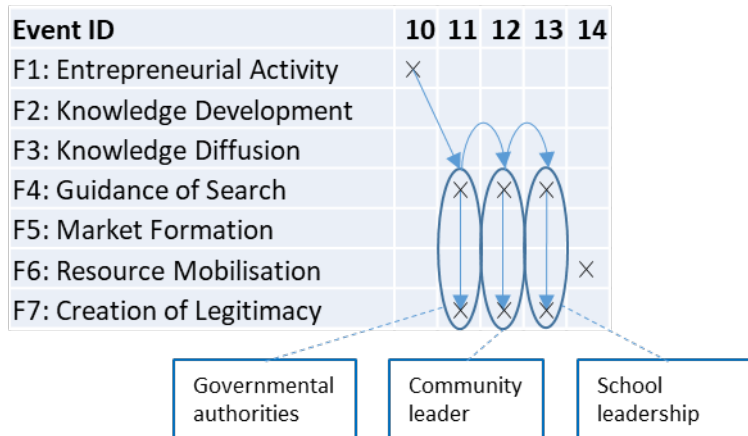


Figure 6-5 Events Map of Stage 1 of Phase 2

Stage 2 starts as meetings are held with governmental authorities (district officials and government stakeholders) to explain the initiative and inform them about the processes of the initiative in order to obtain their buy-in and form trustworthy relationships (F4/GOS and F7/COL). The governmental stakeholders decide to use this initiative as an opportunity to develop the skills of local district officials and as a result, draws up a “Memorandum of Understanding” which underlines the roles and responsibilities of the district officials within the initiative (F5/MF). This memorandum determines that the local district officials are to be included in decision making and that district officials offer themselves as human resources of the initiative where necessary (F6/RM).

Informal discussions with the schools’ principals, deputies and teachers are held to explain the initiative and obtain buy-in from their side (F4/GOS and F7/COL). The events map for Stage 2 is given in Figure 6-6.

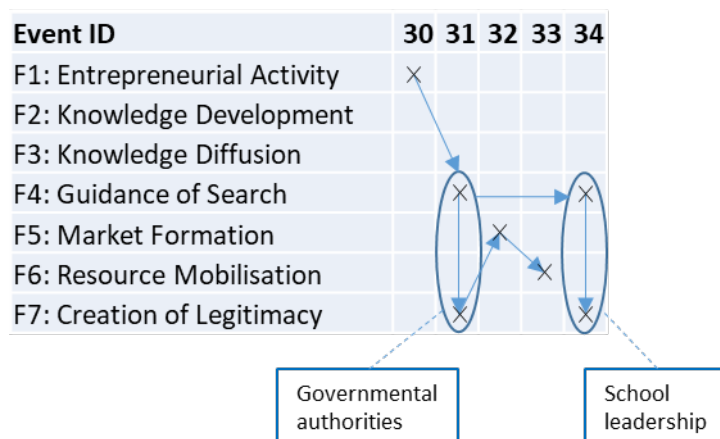


Figure 6-6 Events Map of Stage 2 of Phase 2

Stage 3 starts and as a result of the expansion of the initiative to new schools and areas within the Cofimvaba district (F1/EA), it is necessary to involve the district officials that are

responsible for those areas and schools. Meetings with the new district officials are held to explain the initiative to them and obtain their buy-in (F4/GOS).

With the aim of empowering marginalised communities where possible, specifically within the Eastern Cape Province, the ICT4RED team approaches overseers of the National Rural Youth Service Corps (NARYSEC) programme to work together during the remainder of the initiative (F4/GOS). As part of the NARYSEC programme, youth from rural areas are recruited and equipped with the necessary skills to be able to offer community service within the communities where they live. As a result, the youth, who are part of the NARYSEC programme, become part of the ICT administrator team of the initiative to fulfil the roles of ICT champions within the schools where the initiative is implemented (F6/RM).

Members of the ICT4RED team visit the various new schools to meet with the principals and deputies to explain the initiative to them and obtain their buy-in (F4/GOS and F7/COL). It is explained that as part of the initiative, it would require them to receive the necessary training to equip them to adequately the transition from traditional methods of teaching to using technological resources. These events are indicated in the events map in Figure 6-7.

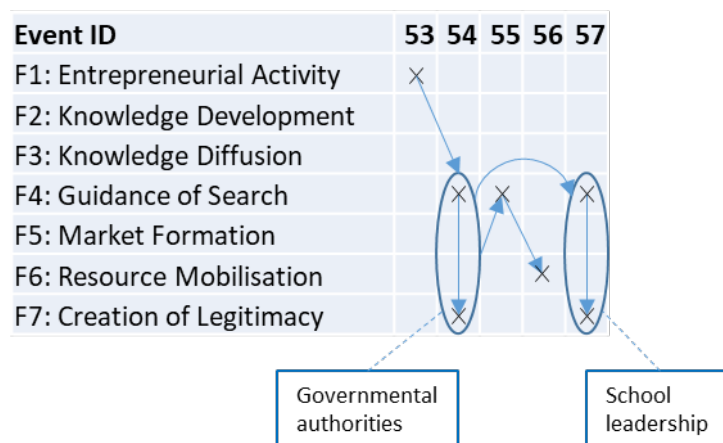


Figure 6-7 Events Map of Stage 3 of Phase 2

The encirclings on the events maps of Stages 1-3 (See Figure 6-5, Figure 6-6 and Figure 6-7) indicate how this phase primarily involves two functions (F4/GOS and F7/COL). Phase 2 focuses extensively on the processes of explaining the initiative and subsequently obtaining the necessary support and buy-in among critical role players to ensure that the initiative can scale among the identified target audience. Depending on these actors, the process may be repeated multiple times, as is seen in all three stages. The unique insights from Stage 2 and Stage 3 reveal how human resources can potentially be involved and pulled into the programme

(F6/RM). In some instances, the government may support the initiative and implement favourable policies (F5/MF) to aid this process, as is the case in Stage 2. In other initiatives, this process is aided by forming partnerships with other organisations (F4/GOS), as is the case in Stage 3. However, Stage 1 shows that the generation of human resources is not a necessity during this stage, however, and this is simply a by-product of the primary focus of obtaining buy-in and support.

6.2.3. Phase 3: Preparation and Training

In Stage 1, during meetings held with the principal, deputy and governing body of the school, it is explained that the principal, deputy and teachers would require training. Training for the principal and deputy is to be held separately from the training to be presented to the teachers. It is decided that training should first be held for the principal and deputy and after the training is presented to them, they will receive homework to do. If they complete the homework, the training for the teachers can be started. As a result, a workshop is held for the school leaders (principal and deputy), along with the ICT champion, during which they receive homework (F3/KDIF). Among the topics covered during the training are sustainability of the initiative, change management, and methods to support and integrate the usage of tablets within the schools. After they received the training, the principal, deputy and ICT champion complete their homework.

As a result, training can now be given to the teachers with the primary aim of equipping them with the necessary skills to be able to use the technology while they teach. Firstly however, literature is consulted and combined with what is known from practice to develop training strategies and material for the training program to be offered to the teachers (F2/KDEV). The program is named the Teacher Professional Development (TPD) and it is started (F3/KDIF). Ten modules are presented by a facilitator known as the Master Trainer at the school for the participating teachers after regular school hours. The modules are particularly concerned with modern teaching methods that are supported by the use of technology. Change management is not separately explained and forms part of the curriculum. During the first training session, the teachers are handed the seven-inch tablets (which were acquired by the Department of Basic Education) to borrow for the duration of the TPD. The tablets are preloaded with content and applications. The content includes all the TPD training modules, documents of the teaching curriculum usually used within the South African educational system and examination papers of years past. Between training sessions, teachers are given homework to complete (F3/KDIF).

The teachers are tasked with applying what they have learned during the sessions within their classrooms and report their findings during the next training session. Attendance of these sessions are monitored and only teachers that attend all the sessions afterwards earn the tablets as their own personal property. The teachers finish training and they graduate (F6/RM). The events map for Stage 1 is given in Figure 6-8.

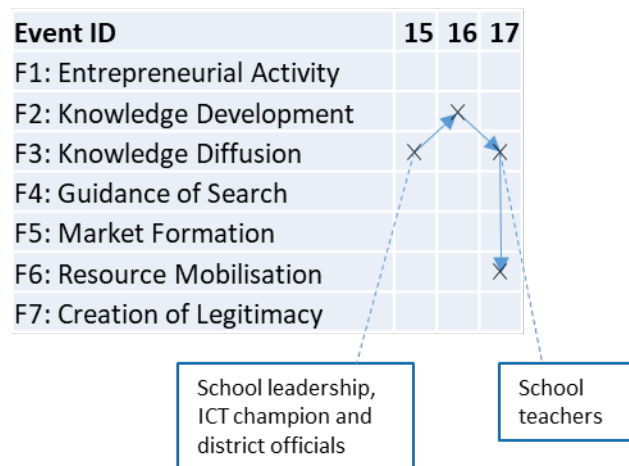


Figure 6-8 Events Map of Stage 1 of Phase 3

For Stage 2, once buy-in is established (during the previous phase), training regarding change management is given to principals and deputies (F3/KDIF) to ensure that they are equipped with the necessary skills to manage the transition from traditional methods of teaching to using technological resources. Similar to Stage 1, they are given homework to do and if it is completed, teachers from their schools can enroll in the training program (TPD) for the teachers.

In parallel to the processes involving the principals and deputies, the district officials (assigned to assist with the initiative by the governmental stakeholders) are met at their office to host a workshop with the aim of providing the necessary training for them (F3/KDIF). The content of the training is sourced and finalised based on feedback from teachers that took part in Stage 1 of the initiative (F2/KDEV) and it is aimed at equipping the district officials with the skills needed to support schools during this stage. As was decided after Stage 1, change management is focussed on separately during the workshop. When the training is completed, the district officials start to prepare schools to use and manage the technologies within their settings, by preparing the schools to take up the technological infrastructure and prepare the school personnel for the change that the technology will bring.

Teachers start with the TPD training program (F3/KDIF), which was also used in Stage 1. The content of the program is similar to Stage 1, however, the structure of the TPD is slightly modified to include an earn-as-you-learn approach where badges are earned by the teacher when they finish a specific section of the training. The choice for using the earn-as-you-learn approach is twofold: Firstly, it develops an attitude where the teachers are willing to work to develop the skills required, and secondly, it makes the teachers feel part of the initiative. Some teachers take initiative and implement their own study groups after school hours to work together to earn badges for themselves and collectively as a school (F3/KDIF). The teachers quickly become accustomed to using the tablets. All of the teachers that started the training, finish it and graduate (F6/RM). The events map for Stage 2 is shown in Figure 6-14.

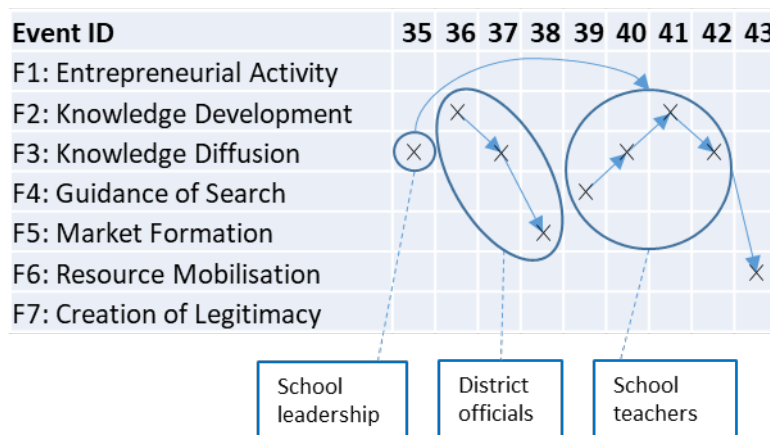


Figure 6-9 Events Map of Stage 2 of Phase 3

At the start of Stage 3, training is presented to the principals and deputies and is specifically focussed on change management. Common change management challenges are discussed. Similar to the two preceding stages, the principals and deputies receive homework to complete (F3/KDIF). Upon completion of homework, the teachers from their schools can enrol to partake in the TPD training course for the teachers.

New ICT champions are assigned to assist the teachers where required when they start to implement technology within their teachings and, as a result, require training to be able to fulfil these roles (F6/RM). A workshop is held where the ICT champions and district officials receive training (F3/KDIF). Both groups receive training specifically aimed at change management, while the district officials receive additional training to be able to assist with the TPD to be held for the teachers.

Teachers start with the TPD training program (F3/KDIF) where the earn-as-you-learn approach is used once again, similar to the previous stage. In parallel to the TPD held for the newly involved teachers, refreshment courses are held for teachers who formed part of Stage 1 and Stage 2 (F3/KDIF). The TPD is well attended throughout its duration and the facilitators, participating teachers and badge collectors work together very well. Teachers also start to engage with other teachers, both from the same schools and other teachers in surrounding areas, co-creating content and sharing their ideas regarding teaching with technology (F2/KDEV). One of the ideas that are discussed is the need for internal support from within the schools that helps with teaching utilising technology. This results in the establishment of internal ICT committees within the schools (F6/RM) that help teachers with co-creation and sharing of the content (F3/KDIF). Change management and leadership courses are held for the teachers and upon finishing these courses, the TPD is concluded (F3/KDIF) and the teachers graduate (F6/RM). The events map of this phase is given in Figure 6-10.

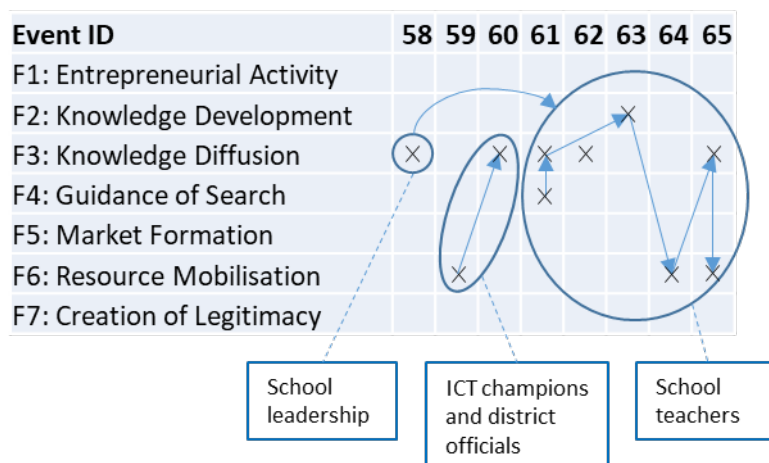


Figure 6-10 Events Map of Stage 3 of Phase 3

As is indicated by the different groupings in each events map (See Figure 6-8, Figure 6-9 and Figure 6-10), this phase is primarily focussed on providing training for different groups of the target audience. In each stage of Phase 3, the stage is started as training is provided to the school leaders, mostly in the form of a workshop as indicated in each of the three events maps (F3/KDIF). Thereafter they receive homework (F3/KDIF). The completion of the homework is a prerequisite before teachers from their school can enroll in their training program. Therefore, the completion of training of the leaders sets the training for teachers in motion.

From Stage 2 onwards, the Earn-as-you-learn policy is developed (F4/GOS) to ensure that the teachers remain engaged throughout the training. The teachers receive the training (F3/KDIF),

and as a result of the earn-as-you-learn policy, some teachers are motivated to earn badges and decide to form their own study groups (F3/KDIF). During Stage 3, the study groups result in some teachers developing their own content and they share it with others (F2/KDEV). They require assistance to share the created content with other teachers and it results in the formation of internal committees in schools (F6/RM) who become responsible for distributing the content. By using the technology during training, the teachers become accustomed to using it and learning-by-using takes place (F2/KDEV).

In parallel to these events, district officials and ICT champions receive training (F3/KDIF) to equip them with the necessary skills to perform their tasks and they become human resources within the school systems (F6/RM). The content of their training from Stage 2 onwards is based on feedback (F2/KDEV) provided by teachers during Stage 1.

6.2.4. Phase 4: Implementation, Usage and Feedback

As a result of the completion of the TPD in Stage 1 of the previous phase, tablets are given to the teachers and schools to be used by the learners (F6/RM) at the start of Stage 1 in this phase. The tablets are transported in a protective casing, known as a MobiKit, which houses 15 tablets. The MobiKits ensures that the tablets are safely kept when transported and because of an installed power system, the tablets can be charged while being moved. The school does not yet have the infrastructure to support the usage of tablets within its teachings. At the school premises, cell phone reception is unstable and not always available. If available, the reception does not extend to 3G or 4G bandwidths. In terms of electricity, the school is connected to a grid connection that is deemed to be good and functional, but requires some marginal corrective maintenance. In order to overcome these issues, supporting infrastructure is gathered and installed (F6/RM). The supporting infrastructure comprises stationary charging lockers in which the tablets are safely charged and stored away when not used, Wi-Fi hubs and small servers (called Mobihubs), a school Wi-Fi network covering all classrooms and a content server. The learners are handed the tablets and they start to use them during their classes (F2/KDEV).

In order to manage the distribution of tablets more effectively, the school appoints an ICT committee to take responsibility for distribution and management of the tablets and make decisions of what grade, class and subject would make use of the tablets and when it would

happen (F6/RM). They are also responsible for managing technical issues. The assigned ICT champion also provides assistance to teachers where necessary.

A self-evaluation report is given to learners, teachers, principal and deputy of the school, district officials and community leaders to complete to provide feedback for improved design of the initiative once the tablets start to become integrated into the teaching of the school (F2/KDEV). A specific meeting with the principal and teachers is held to find out from their view what worked and what did not (F2/KDEV). Further feedback regarding the Wi-Fi, routers and lockers are provided by these role players (F2/KDEV).

Upon reflection on the TPD it is realised that the facilitator of the trainings did not always have enough time to follow up on the teachers' usage of the tablets in their classes, since he/she is under pressure to present the modules in the allocated time. As a result, teachers did not always integrate or applied what was learned into their teachings in class. It is also realised that change management is especially crucial as a result of the disruptive nature of the tablets on teaching methods. It is decided that in the future, it will be taught separately from the other modules.

The lessons, feedback and results from the stage are synthesised, resulting in the adaption of the implementation model (discussed in Stage 0) that guides the processes of the initiative (F2/KDEV). The adaption of the model expands the number of components to 12 instead of the initial seven. The model now consists of the following components: Project Management, Change Management, Operations Management, Evidence-based Policy, School ICT Infrastructure, Teacher Professional Development, Communication, Community Engagement, Network, Content, Monitoring & Evaluation and Stakeholder Management. The model is also renamed and becomes the "ICT4RED 12-Component Model". As a result, additional project champions for each new component are selected and they form part of the core research team of the initiative (F6/RM).

An ethnographic study was done a year prior to the teachers and learners using tablets and a year after the tablets were implemented (F2/KDEV). The results of the study show that many positive behavioural changes occurred as a result of the implementation of tablets among teachers and learners alike (F7/COL).

Before the initiative is expanded to the new schools during the next stage, a change is made as the 7-inch tablets from the previous stage are replaced with 10-inch branded tablets. The manufacturers of tablets do not matter – instead the implantation team of the initiative draws up the desired specifications for tablets for the initiative. Before any tablet can potentially be acquired it is measured against the drawn-up standard. The suitable tablets are selected and acquired (F6/RM). Suitable content is selected and loaded onto the tablets (F2/KDEV). The events map for Stage 1 is given in Figure 6-11.

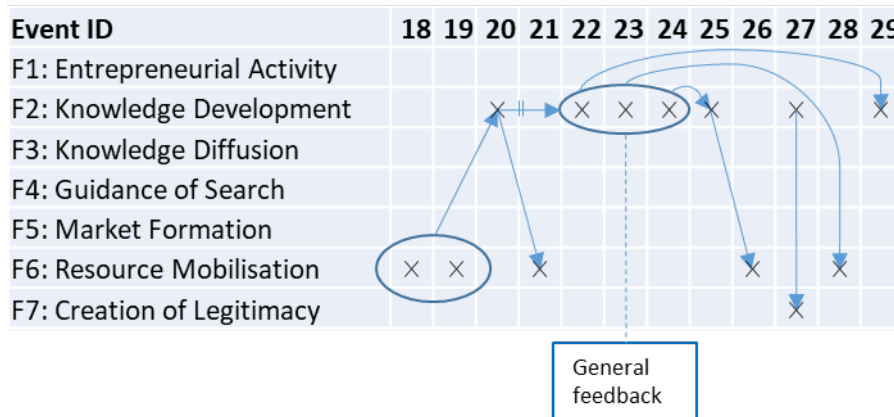


Figure 6-11 Events Map of Stage 1 of Phase 4

At the start of Stage 2, once teachers finish the TPD in the previous phase, they are ready to teach learners while using the tablets and tablets are distributed to the schools (F6/RM). Supporting infrastructure is also installed at the school premises (F6/RM). The primary goal is to provide charging facilities and secure storage for the tablets when they are not used. Similar to Stage 1, the supporting infrastructure is stationary charging lockers, in which the tablets are safely charged and stored away when not used, Wi-Fi hubs and small servers (called Mobihubs), a school Wi-Fi network (covering all classrooms) and a local content server. Many of the schools decided that it is not safe to allow learners to take the tablets home and as a result it is necessary to provide a safe overnight storage area for the tablets. The charging lockers serve this purpose. The content server synchronises with a central server during the night when there are no users on the server. The teachers and learners can therefore access the content as it becomes available on the content server. Each school appoints an ICT committee to fulfil the role of managing the distribution of tablets among the various grades and classes (F6/RM). It is decided that the teachers must be competent with using the tablets when they teach at their schools before the learners can receive tablets to use during their studies. As the initiative

evolves, the teachers become more accustomed to using the tablets in class and the learners begin to use the tablets in classes (F2/KDEV).

Various role players of the initiative during this stage provide feedback (F2/KDEV). Throughout this stage, the district officials remain very committed to offer support where needed and their support is seen as a critical success factor of this stage. It results in the formation of many trustworthy relationships between the officials and the ICT4RED team, principals, deputies and teachers (F7/COL). The implementation model (ICT4RED 12-Component Model), which is being developed throughout the initiative as an artefact, guiding similar initiatives in the future, is adjusted based on the lessons learned and feedback gathered during this stage. The model is converted to a framework by explaining and demonstrating the relationships between the various components and is called the ICT4RED Implementation Framework (F2/KDEV). The events map of Stage 2 is given in Figure 6-12.

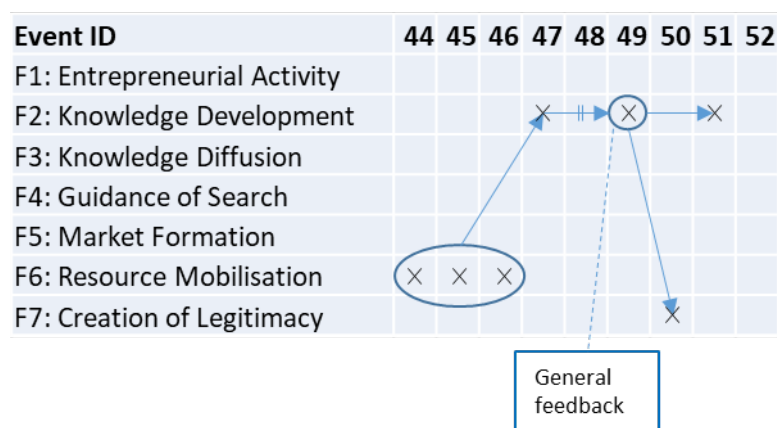


Figure 6-12 Events Map of Stage 2 of Phase 4

Similar to the previous two stages, in Stage 3, once the teachers finish the TPD, the schools are deemed ready for the next step of the initiative and they receive the tablets (F6/RM). As was the case in the preceding stages, supporting infrastructure is required at the school premises to support the usage of the tablets while teaching. These are stationary charging lockers, Wi-Fi hubs and small servers (called Mobihubs), a school Wi-Fi network covering all classrooms and a local content server. The supporting infrastructure is installed (F6/RM).

When the installation of the supporting infrastructure is finished, the teachers start to use the tablets as part of their teaching methods. Unlike Stage 2, the teachers do not have to prove their competence with using the tablets while they teach before the learners can use the tablets in

class. As a result, learners immediately start to use the tablets during their studies. Similar to the preceding stages, the ICT committees within the schools (that have already been established during the TPD) manage the distribution of tablets among the various grades and classes. Some teachers continue to take initiative by co-creating additional learning material that can be used by other teachers (F2/KDEV). Teachers start to utilise the co-created material and find new innovative ways to teach learners using ICT technologies: It is noted that the teaching methods of the teachers start to change as they incorporate the usage of the tablets and the new teaching strategies they were exposed to during training in their teachings. They start to create and share videos in classes, regularly download new content from the content server and do online assessments (F3/KDIF). Some of the teachers state that these changes have a significant and positive impact on the attitude of the learners and that their attention span increase (F2/KDEV and F7/COL). Almost all of the teachers mention that they have become increasingly comfortable with using the tablets and teaching strategies in ICT learning. It is evident that the initiative results in an increased positivity towards using technology as part of learning methods among the teachers (F7/COL). From the schools' point of view, it is reported that a positive change is brought forth by the initiative with regards to actions from district leaders. It is reported that, since the initiative started, the district leaders often collaborate with the schools and their personnel and that they regularly visit the various schools. The district officials regularly offer moral support, support with the implementation of tablets during teaching methods and offer strategic input regarding keeping the tablets safe. According to the teachers, this was not previously the case. This strengthens belief among the schools that the initiative has brought forth positive changes, even at organisational level (F7/COL). The events map of Stage 3 is given in Figure 6-13.

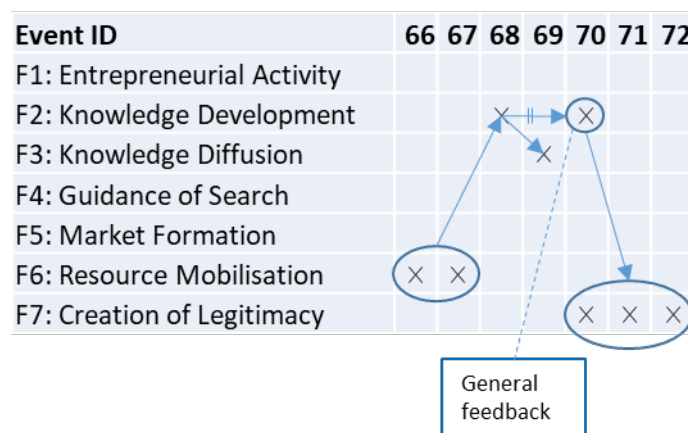


Figure 6-13 Events Map of Stage 3 of Phase 4

Drawing on the insights from each of the three stages, it is seen that within each of the three phases, the tablets and supporting infrastructure are implemented within the schools (F6/RM). This is followed by the teachers and learners becoming more accustomed to using the technology. This leads to learning-by-using (F2/KDEV). An isolated result of these events occurs during Stage 3: Some teachers begin to collaborate with others, and they create their own content (F2/KDEV) that can be used by other teachers that are also partaking in the initiative. As a result, with the help of the previously established ICT committee, they share their content (F3/KDIF).

During the latter parts of each stage, feedback is gathered from the different actors involved during the particular stage (F2/KDEV). The feedback after Stage 1 results in the most significant changes of the initiative. However, it is to be expected, since Stage 1 is the first attempt to scale the initiative. Firstly, the implementation model is adapted (F2/KDEV) and new components are added. Subsequently, new human resources in the form of component ICT champions (identified youth from the community who completed school and are knowledgeable about ICT) are recruited to assist schools (F6/RM). The feedback also results in the change of technology to be used and new, improved tablets are acquired (F6/RM). Lastly, for Stage 1, based on the feedback, new learning content for the tablets are sourced and uploaded (F2/KDEV). An ethnographic study (F2/KDEV), which is also a form of feedback, shows how the behaviour of teachers and learners have positively changed (F7/COL). Similar to Stage 1, feedback from Stage 2 also results in the adaption and further development of the implementation model (F2/KDEV). Feedback during Stage 2 and Stage 3 shows that trustworthy relationships have been formed (F7/COL) between the different actor groups (district officials and school personnel). During Stage 3 (similar to Stage 1) it results in the revelation of the positive changes that the initiative brought forth, thus developing advocacy among the target audience (F7/COL).

6.2.5. Phase 5: Project disengagement and handover

At the latter part of Stage 3, the ICT4RED team starts a blog that allows them to communicate their findings and developments of the initiative on an internet platform (F3/KDIF and F4/GOS). Furthermore, they engage with various practitioners who specialise in ICT developments within education and share the research outputs (artefacts) that have been developed so far. As a result, the team is invited to both local and international gatherings of practitioners that specifically focus on ICT within education, where they share their findings.

The ICT4RED team informs the relevant stakeholders of the Cofimvaba school district (district officials and Eastern Cape Department of Education officials) that they need to develop a sustainability plan and strategy to ensure that the initiative continues in a lasting and sustainable manner. Their responsibilities will include to provide continuous support to the ICT champions at the schools and to manage the ICT infrastructure such as tablet upgrades and problems, internet and Wi-Fi connections and train new teachers who will partake in the initiative in the future. Governments from other provinces in South Africa also approach the ICT4RED team to use their training resources for teachers of their provinces with the plan to ultimately expand the initiative to other schools in their regions (F5/MF). As Stage 3 concludes, students from various research institutes start to use the initiative in their studies (F3/KDIF), which in turn communicates the success of the initiative to different audiences (F7/COL).

The ICT4RED implementation framework is finalised and can be used to guide the implementation of similar initiatives in the future (F2/KDEV). The handover of the initiative takes place and the stakeholders take responsibility to manage the 26 schools that have been involved in Stages 1-3. The stakeholders begin to explore possibilities of expanding the initiative by involving other districts within the Eastern Cape Province. These events are illustrated in the events map in Figure 6-14.

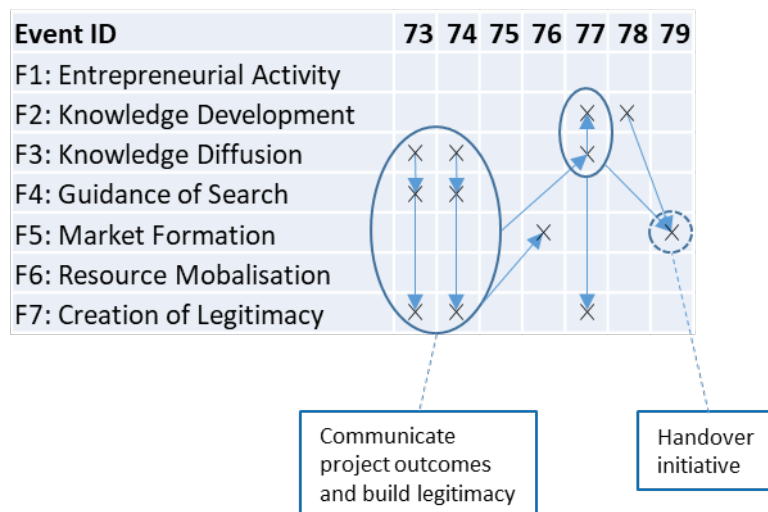


Figure 6-14 Events Map of Phase 5

As indicated in the first circle in the events map in Figure 6-14, the following pattern occurs twice at the beginning of the stage: The ICT4RED team acquires a platform (by starting their own blog and by invitation to a conference) on which they communicate the outcomes of the initiative and the resulting research findings (F3/KDIF and F4/GOS). This builds legitimacy

around the positive effect of the initiative among the audiences of the platforms (F7/COL). Arguably as a result thereof, governments of other provinces approach the ICT4RED team to make use of their training resources, with the aim to implement similar initiatives in schools within their districts (F5/MF). Furthermore, students collaborate with the ICT4RED team (F3/KDIF) and start to use the initiative in their studies, resulting in an increase in academic research related to ICT in education (F2/KDEV). This helps to further develop legitimacy around the positive effect of the initiative (F7/COL).

In addition to the aforementioned proceedings, a final document is developed to assist and guide the people taking over responsibility of the initiative or to be used in guiding future initiatives (F2/KDEV). This further contributes to the eventual hand-over of the project and its operational responsibilities to the relevant stakeholders (F5/MF). It is recognised that the development of the framework can only be made possible by feedback and gaining knowledge from actors in the system which refers to events preceding this particular sequence.

6.3. Case Conclusion

Using the insight gained in Section 6.2 and the events maps of the different stages and phases, the overall CLD of the case can be constructed. The causal chains and causal loops present in each phase are indicated with red arrows in each CLD. This process is started within Phase 1, where there is a big emphasis on research and preparation, resulting in many knowledge development activities (F2/KDEV). These activities in turn lead to the raising up of human resources as a project team is assembled (F6/RM), who further develops the model according to which the rest of the project will be implemented (F2/KDEV). The functional fulfilment of this phase is indicated in red in the CLD of this case in Figure 6-15.

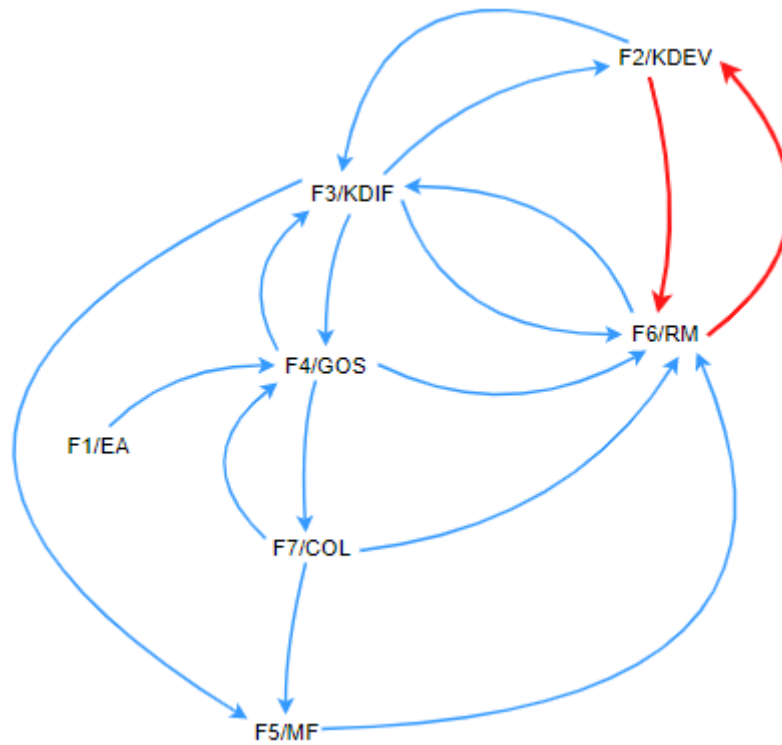


Figure 6-15 Phase 1 - Research and Preparation

Phase 2 is characterised by the emphasis of forming trustworthy relationships by engaging with different members of the target audience and explaining the initiative to them. This further results in advocacy regarding the initiative. Stage 1 can be seen as the standard procedure when obtaining buy-in: The initiative is explained (F4/GOS). This leads to the formation of advocacy coalitions or trustworthy relationships (F7/COL). This process is repeated as many times as necessary (as indicated by the closed loop), starting with the governmental authorities. Stage 2 also shows how governmental efforts (F5/MF) can assist to obtain support for the initiative that may result in the raising of additional resources and support, while Stage 3 shows how forming partnerships with other actors (F4/GOS) can have the same effect. The causal loops uncovered during this phase are indicated in Figure 6-16.

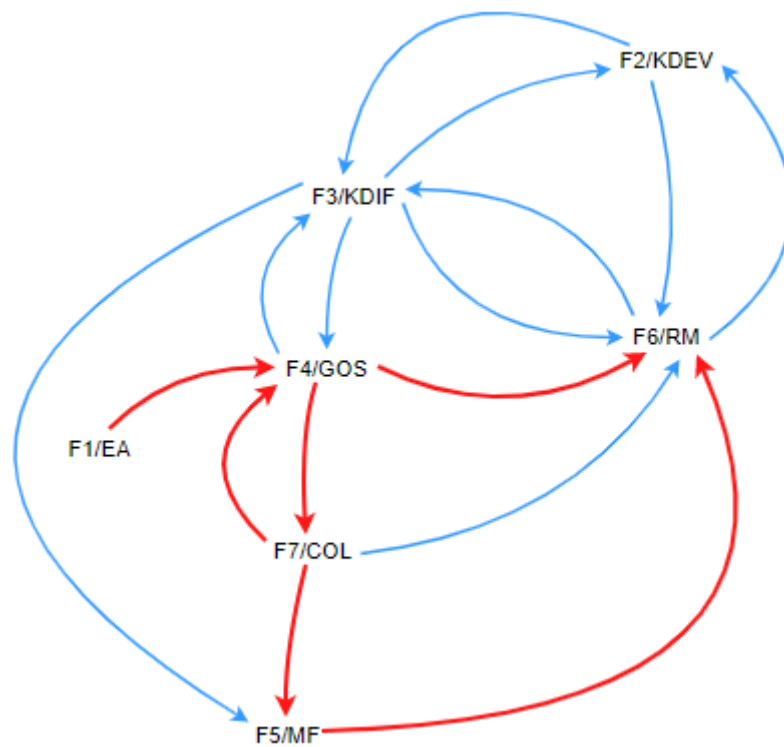


Figure 6-16 Phase 2 - Obtaining Buy-in from Target Audience

In Phase 3, The CLD of Stage 1 reflects this phase in its simplest form. From Stage 2 onwards, the “earn-as-you-learn” approach is introduced. In addition, teachers start to partake in the initiative, creating and sharing their own content, resulting in a unique alteration within the feedback loops and CLDs of Stage 2 and Stage 3. The CLDs of each stage are used to construct a combined CLD of this phase, illustrated in Figure 6-17.

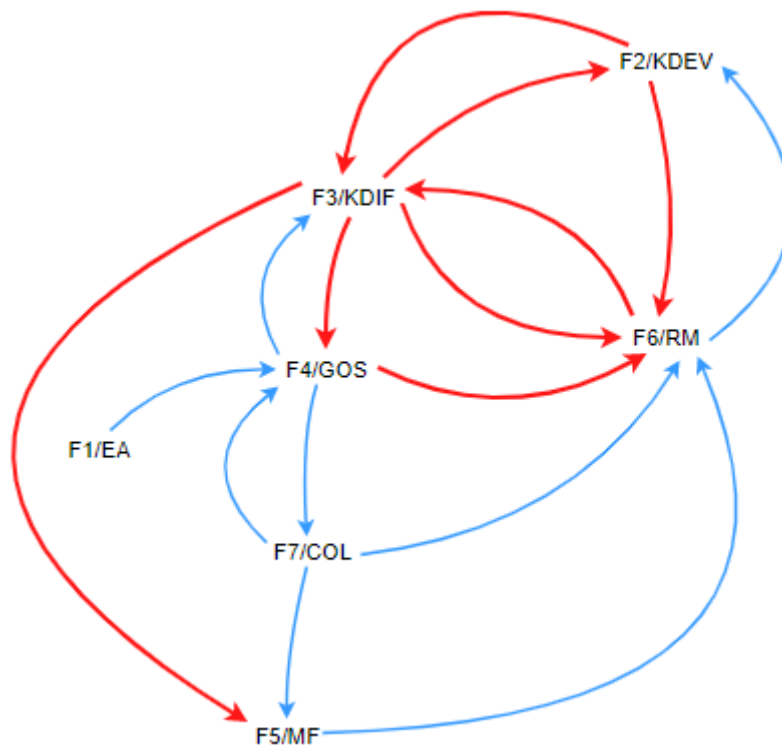


Figure 6-17 Phase 3 - Preparation and Training

Within each of the three stages of Phase 4, the tablets and supporting infrastructure are implemented within the schools (F6/RM). This is followed by the teachers and learners becoming more accustomed to using the technology. This leads to learning-by-using (F2/KDEV). An isolated result of these events occurs during Stage 3: Some teachers begin to collaborate with others and they create their own content (F2/KDEV) that can be used by other teachers who are also partaking in the initiative. As a result, with the help of the previously established ICT committee, they share their content (F3/KDIF).

During the latter parts of each stage, feedback is gathered from the different actors involved during the particular stage (F2/KDEV). The feedback after Stage 1 results in the most significant changes of the initiative. However, it is to be expected, since Stage 1 is the first attempt to scale the initiative. Firstly, the implementation model is adapted (F2/KDEV) and new components are added. Subsequently, new human resources in the form of component ICT champions (identified youth from the community, who completed school and are knowledgeable about ICT) are recruited to assist schools (F6/RM). The feedback also results in the change of technology to be used and new, improved tablets are acquired (F6/RM). Lastly, for Stage 1, based on the feedback, new learning content for the tablets are sourced and

uploaded (F2/KDEV). An ethnographic study (F2/KDEV), which is also a form of feedback, shows how the behaviour of teachers and learners have positively changed (F7/COL). Similar to Stage 1, feedback from Stage 2 also results in the adaption and further development of the implementation model (F2/KDEV). Feedback during Stage 2 and Stage 3 shows that trustworthy relationships have been formed (F7/COL) between the different actor groups (district officials and school personnel) and during Stage 3 (similar to Stage 1), it results in the revelation of the positive changes that the initiative brought forth, thus developing advocacy among the target audience (F7/COL). The combined CLD for Phase 4 is given in Figure 6-18.

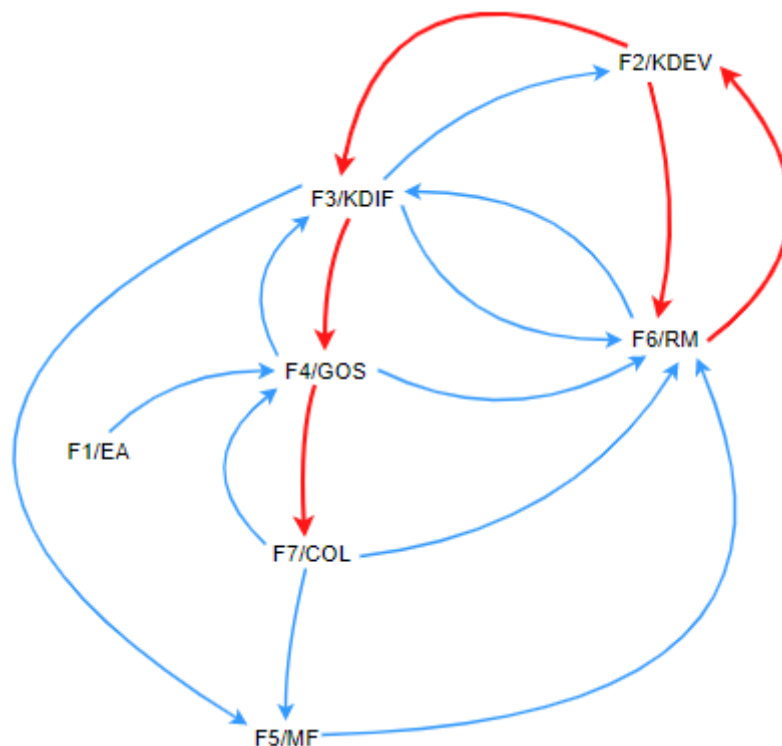


Figure 6-18 Phase 4 - Implementation, Usage and Feedback

As the initiative draws to a close in Phase 5, the research findings and outcomes of the initiative are communicated to the public (F3/KDIF and F4/GOS) and build advocacy regarding the project (F7/COL). As a result, more researchers start to use the initiative in their studies (F2/KDEV and F3/KDIF), which assists in further developing of advocacy (F7/COL). This in turn results in the desire among governments of other provinces to use the initiative and its principles within their areas, and the initiative gets handed over (F5/MF).

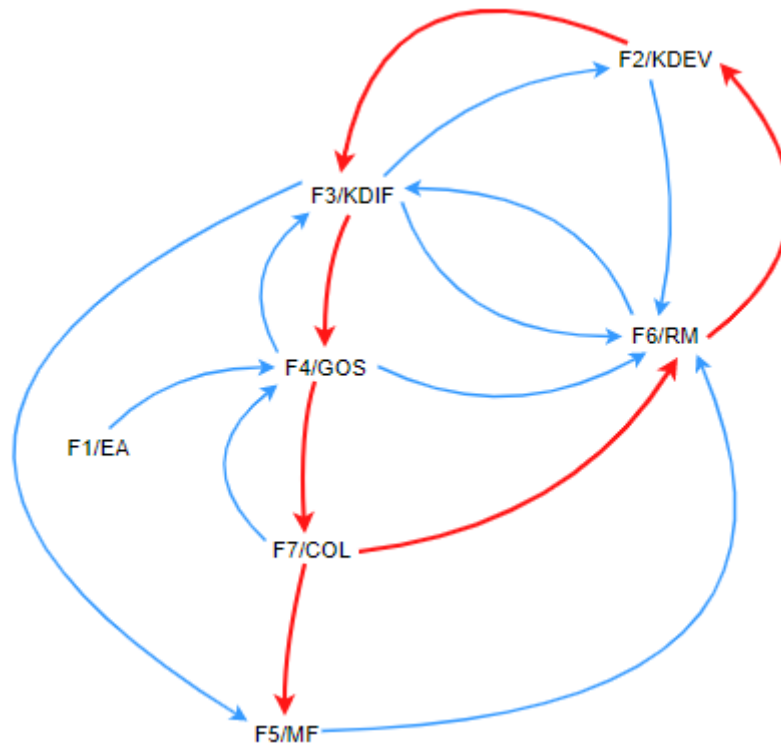


Figure 6-19 Phase 5 - Project Disengagement and Handover

In addition to the functional dynamics, the cumulative fulfilment of the functions is mapped across the events to obtain the trend pattern of the case. This is given in Figure 6-20. The pie charts indicate what functions are present during the different phases. Because the same phases occur during different stages, the event IDs do not follow sequentially on one another. For example, the events IDs of the training phase are 15-17 (Stage 1), 35-43 (Stage 2) and 58-65 (Stage 3). Figure 6-20 shows how Phase 1 focusses extensively on knowledge development (F2/KDEV), Phase 2 primarily on guidance of search (F4/GOS) and creation of legitimacy (F7/COL), Phase 3 on knowledge diffusion (F3/KDIF) in particular, Phase 4 on the allocation/mobilisation of resources (F6/RM) and knowledge development (F2/KDEV), and lastly Phase 5 on knowledge development and diffusion (F2/KDEV and F3/KDIF). These are followed by guidance of search and creation of legitimacy (F4/GOS and F7/COL) and then market formation (F5/MF) as the initiative gets handed over.

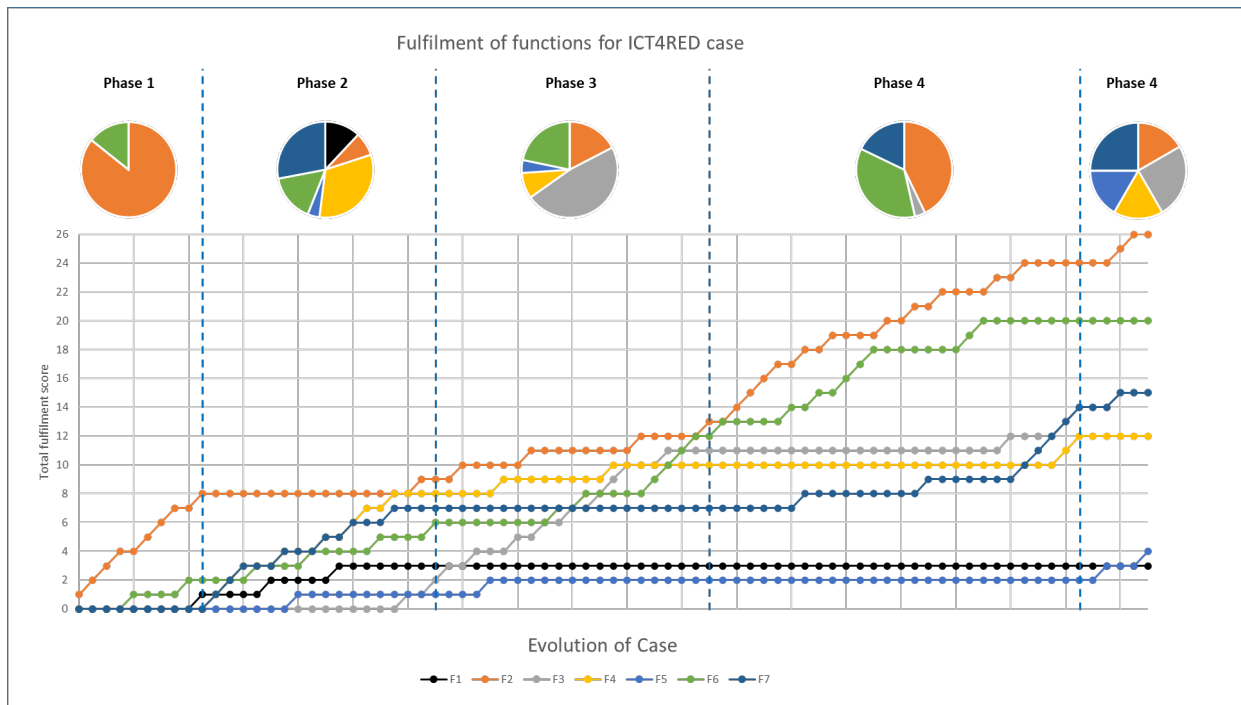


Figure 6-20 Functional Fulfilment of ICT4RED Case

6.4. Chapter Summary

In this chapter, the second case study – ICT4RED – is analysed according to the first four steps of the EHA method explained in Section 2.1 and 4.1, to identify key events in the development and evolution of the ICT4RED initiative. Section 6.1 provides the background and purpose of the project. In Section 6.2, the data collection and database construction for the case are discussed, the events are mapped to the different system functions, and five different phases are identified. The interaction patterns are also identified and given in the form of events maps for each phase. Conclusions are made and the overall CLD of the case is given in Section 6.3, along with the trend pattern of this case.

Chapter 7

Case C: Stock Visibility Solution (SVS)

In this chapter, the third and final case study is analysed using the analytical approach discussed in Chapter 4. An introduction of the case study is provided in Section 7.1. Within Section 7.2 the events of the case are related to the functions they fulfil. The case is then divided into five phases and for each phase an events map is given to identify the causal chains and feedback loops of the specific phase. In Section 6.3, the causal chains and feedback loops are used to construct a CLD of the case that illustrate the narrative of the core dynamics identified as the case evolved over time.

7.1. Introduction to SVS Case Study

During the latter part of 2012 and beginning of 2013, the Mthatha medical depot crisis occurred in the Eastern Cape, where staff of the depot went on strike because of poor management. The result of this depot crisis was stock-outs or shortages of crucial antiretroviral (ARV) and tuberculosis (TB) drugs in approximately 300 medical facilities that were supplied by the depot (Medecins Sans Frontiers *et al.*, 2013). In response to the crisis, the Stop Stockouts Project (SSP) was initiated in 2013. The program helped to monitor the availability of “all essential primary healthcare medicines and children's vaccines by conducting annual telephonic surveys and logging reports through its SSP hotline” (Nolting, Grobbelaar and van Vuuren, 2018). The SSP provided the National Department of Health (NDoH) of South Africa with the gathered information in order for the department to attend to inadequate services as experienced by public members (Nolting, Grobbelaar and van Vuuren, 2018).

Stock-outs remained a problem and in 2014, it seemed that the NDoH recognised it as an extended problem that requires attention. In response, the department asked multiple companies to help develop solutions to relieve and solve this problem that can be implemented on a national front. As a result, the Chronic Medicine Dispensing and Distribution (CCMDD) programme was developed, introduced and implemented during the latter part of 2014. (National Department of Health, 2015)

The CCMDD programme is aimed at improving the accessibility of medicine to chronic patients by allowing them to register for the programme so that they can collect their medication from distribution outlets placed at strategic and convenient locations (Health Systems Trust, 2019). Furthermore, it alleviates the problem of public congestion at public health facilities. This is done by shifting the responsibility of distribution of the medication from public health facilities to external service

providers that dispense and distribute the medications from various central points (Health Systems Trust, 2019). At the end of 2014, the CCMDD programme was responsible for the prescription of 183 989 registered patients (National Department of Health, 2015).

Even though accessibility of medicine improved, stock-outs still remained a problem. In 2015 the *Stock Outs National Survey* reported that on the day that the survey was run, 20% of health facilities experienced or were affected by stock-outs of TB and ARV medicines, while 10% of facilities indicated that they ran out of vaccines (Govender, 2016).

In 2016, it was necessary for a proactive solution that monitors medical drugs in health facilities of the country and Mezzanine Ware in partnership with Vodacom and the NDoH developed the Stock Visibility Solution (SVS) (National Department of Health, 2016). The SVS is a mobile and web-based application and analytical tool that is used to provide real-time visibility by tracking the levels of stock of drugs in clinics within eight of the nine provinces of South Africa through using mobile phones (Mezzanine, 2020a). Smartphones and the uploaded application package are distributed to the various clinics where the phones are used to scan barcodes of the various medicine at the clinics and with the help of Vodacom's broad mobile network, the information is sent and stored on a central database. The information is stored on the mobile devices until it can connect to the mobile network that allows it to be uploaded onto the central database. Through the mobile mHealth app, SMS notifications and automated alerts are scheduled if low stock levels appear (Chowles, 2016). It also allows for a real-time update regarding the available stock of essential drugs for all the connected clinics by sending SMS and email notifications to relevant district and provincial government authorities (Chowles, 2016). In turn, clinics that are low on stock can be identified and flagged as "high priority" for resupply of the necessary drugs. Furthermore, clinics that constantly face stock-outs can be identified and investigated by supply chain managers of the NDoH. The SVS works online and offline, which makes its usage ideal in rural and resource constrained areas (Mezzanine, 2020b). (National Department of Health, 2017)

The public health structure of South Africa consists of different ministries of health on different levels – national, provincial, district etc. The members within these ministries play an integral part in the operations of the SVS. Five levels of management are identified within this structure that are involved in the solution. These levels of management are on national- (highest), provincial-, district-, sub-district- and facility level (lowest). Within each of these five management levels, there is a hierarchy of managers and members, each fulfilling a different role. The involvement within the SVS is illustrated in Figure 7-1. Not all members of management or members of the ministries are involved

in the solution and those that are involved are indicated by a black icon and a red dot. The working of the solution is as follows: A mobile user works at one of the public healthcare facilities in the country where the SVS is implemented. Information regarding available stock is tracked throughout the week by using a bin card. Whenever new medicine enters or exits the store room, it is written on the bin card. Once a week a mobile user captures data of the available stock at their facilities electronically on a mobile device by scanning a barcode that is attached to the medicine and then inserting the amount of stock that is left on the mobile application (Chowles, 2016). The expiry dates of the medication are also inserted. The available stock is updated onto the SVS's electronic system that enables various managers to track the amount of stock available at the various facilities. The mobile user is required to report to the facility manager, since the facility manager must ensure that the data is logged onto the system on a weekly basis. In turn, the facility manager must either report to the local area manager or the sub-district manager, depending on the roles assigned within the sub-district (in some cases one person is required to fulfil both roles). The managers at sub-district level act as mediators between facilities and districts. If any problems are identified among facilities, the facility manager is contacted and they work together to solve the problem. Furthermore, once they receive the stock availability reports, they go through it to see which facilities are low on stock. The facility managers are contacted to ask if they have ordered stock from the depot that supplies them. The role of the district pharmacist is to monitor the stock availability data generated by the SVS and alert sub-district managers about facilities that do not submit reports. They also use the data to order new stock to be distributed among facilities. The district manager is tasked with reporting stock availability and reporting coherence of the facilities to the provincial management members, who in turn must report to national management. The district managers also report the availability of stock to other district managers. Provincial and national government oversee these processes. The success of the SVS is dependent on the communication among the district management, sub-district management and facility management. (Data Innovator, 2017; Iwu *et al.*, 2020)

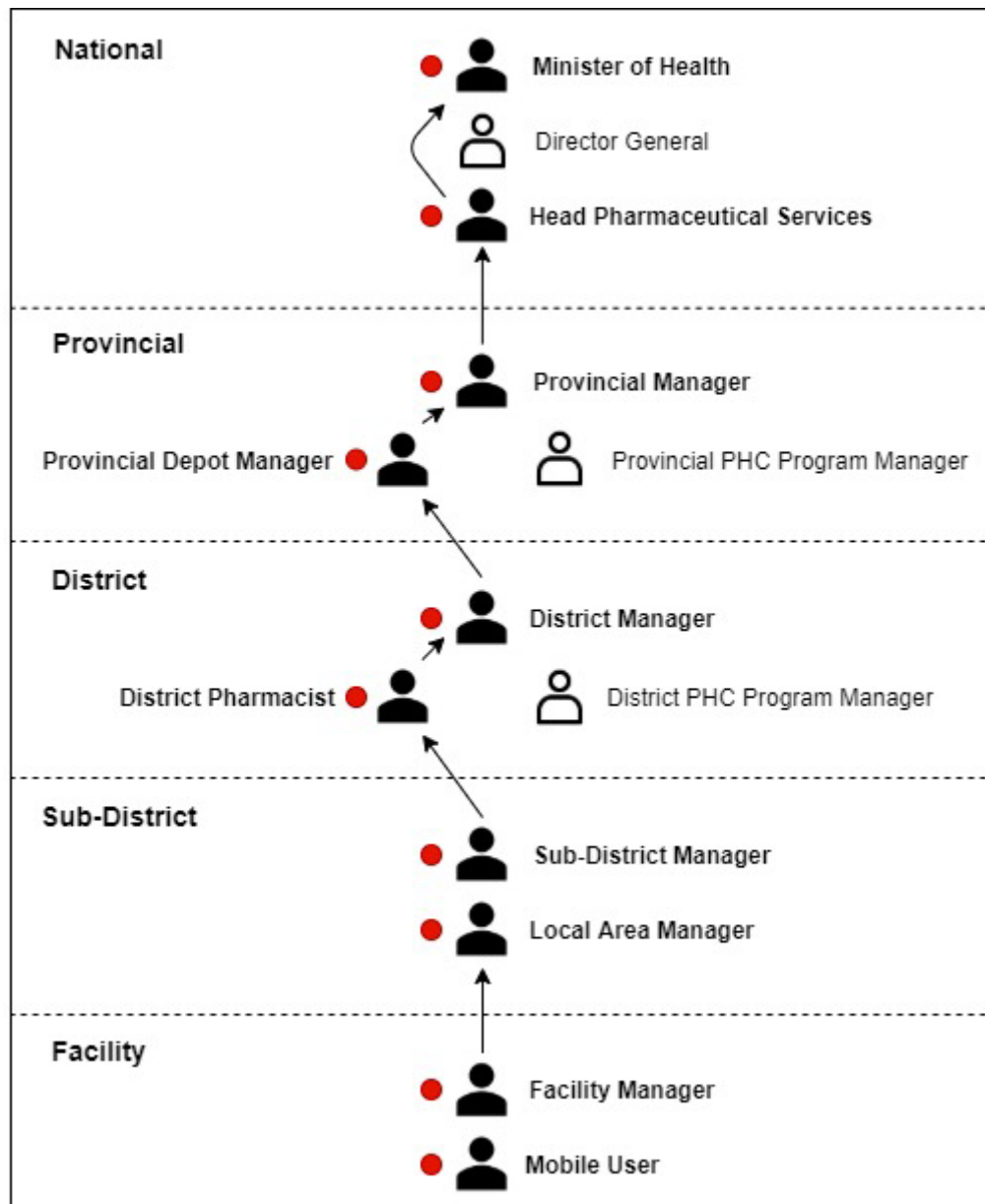


Figure 7-1 Management and User Involvement within SVS [Adapted from (Data Innovator, 2017)]

Since its implementation, the SVS is active in approximately 3300 clinics within South Africa with an adoption success of more than 90% (Mezzanine, 2020b, 2020a). Currently, the solution is also being scaled in Zambia and Kenya (Mezzanine, 2020a) under the name of “SMS for Life” (GSM Association, 2018). (However, this particular case deals with the implementation of the SVS within South Africa only.) It is stated that since the inception of the SVS program, the availability of ARV medication increased from 69.5% to 92.5%, while the availability of TB medication increased from 65.7% to 88.5% (National Department of Health, 2017; Nolting, Grobbelaar and van Vuuren, 2018).

7.2. Data Analysis

The data for this case is gathered from various resources that are found in research databases and the public domain. The SVS has been used in tertiary research studies and as a result, theses, conference papers and articles have been written about the solution. The GSMA (Groupe Speciale Mobile Association) completed a case study report that is available in the public domain. Within this report, the different stages of the development of the solution are described that form the basis of the case study and allows the division of the data into different timeframes.

In total, 67 events are identified in the literature that constitute the SVS case presented in this document. These events are sorted chronologically and are given in Table 12 in Appendix A.

In total, five phases are identified according to the process explained in Section 4.1.4 and are as follows:

- Phase 1: Idea development
- Phase 2: System and higher-level management preparation
- Phase 3: Training and implementation within facilities
- Phase 4: Shaping and adaption
- Phase 5: Post-uptake feedback

The implementation of the SVS takes place in two separate stages. The first stage is a pilot of the solution that is implemented within three provinces. The second stage is a nationwide implementation of the solution within eight of South Africa's nine provinces. Two phases encompass these implementations – Phase 2 and Phase 3. Phase 2 deals with all the necessary preparation of the system at higher level so that implementation can occur at facility level in Phase 3. Phase 3 therefore deals with the implementation of the solution at facility level. To implement and scale the solution at facility level, three levels of management are involved: district, sub-district and facility.

The way the phases develop is illustrated in Figure 7-2. As this figure shows, the case is started by the *Idea development* phase, where the SVS is conceptualised and finalised for the initial pilot implementation. This phase is followed by the *System and higher-level management preparation* phase and the *Training and implementation within facilities* phase, which both take place during the pilot project (Stage 1). The pilot stage is used to prove to the NDoH that the solution is viable and can be implemented nationwide. Therefore, once the pilot is finished at the conclusion of the *Training and implementation within facilities* phase, the implementation of the solution can take place on

national level, signalling the start of Stage 2. Therefore, in order for this to take place, the *System and higher-level management preparation* phase takes place once more. This is followed by the *Training and implementation within facilities* phase. Thereafter, the *Shaping and adaption* phase occurs, and the case concludes with the *Post-uptake feedback* phase.

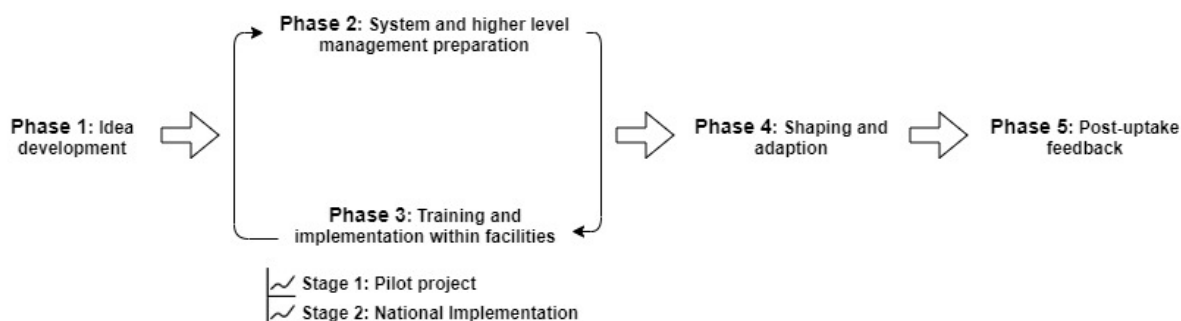


Figure 7-2 Sequential development of phases in SVS case

At the time of writing, the solution is still in use across eight provinces in South Africa and the NDoH continues to manage it. The last phase that is identified based on the available information are the *Post uptake-feedback* phase. Since the solution is still in use, this phase does not represent the end of the intervention. It is however the last phase for this case study.

7.2.1. Phase 1: Idea Development

The SVS initiative is started as the Vodacom Foundation makes funding available to the NDoH to support the department with the nationwide problem of stock-outs of TB medicine, vaccines and ARV drugs (F1/EA and F5/MF). The Vodacom Foundation has relationships with various companies that aim to provide health solutions, of which Mezzanine is one, and they are approached to collaborate and work together to develop a solution to the stock-out problem (F1/EA). Relationships between Mezzanine and Vodacom (private organisations), and the NDoH (public organisation) are established to form a public-private partnership (PPP) network (F3/KDIF). Collaboration between Mezzanine and Vodacom takes place to come up with design of the solution and name it the Stock Visibility Solution (F2/KDEV and F4/GOS). The design is proposed to the NDoH (F3/KDIF), after which the support of the SVS is gained directly from the Minister of Health of South Africa by Mezzanine (F5/MF).

Before the government decides to fully finance the scaling of the SVS within all relevant health facilities countrywide, they negotiate with Mezzanine and Vodacom to start with a “small-scale implementation”, which takes place during the “proof of concept” (PoC) phase. The PoC phase is seen as a pilot which serves as a trial period to see if the solution will be successful (F2/KDEV). The

government state that they seek evidence that demonstrate the effectiveness of the solution. According to them, enough evidence would be if the solution successfully scales within at least 200 different health facilities (F4/GOS).

The events map of Phase 1 is given in Figure 7-3. This phase is started against the backdrop of the stock-out problem that South Africa faced since the end of 2012 that continues up to 2016. As Figure 7-3 shows, this problem acts as the catalyst (F5/MF) to start this project and funding is secured as a result, as shown by the grouping of entrepreneurial activities (F1/EA). This results in the formation of partnerships (F3/KDIF), collaboration and ultimately the forming of the design of the solution (F2/KDEV and F4/GOS). The design of the solution is presented to government (F3/KDIF) that leads to gaining their approval and securing their willingness to partake in the solution (F5/MF).

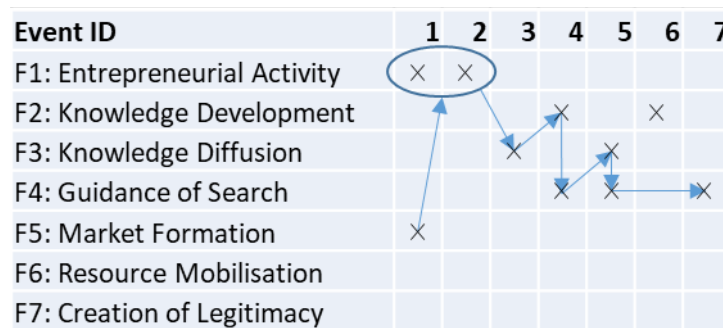


Figure 7-3 Events Map of Phase 1

7.2.2. Phase 2: System and Higher-Level Management Preparation

The first stage starts as roles during the PoC phase are set out: Vodacom partly finances the PoC phase (F6/RM), while the rest of the funding is provided by seed donors (F6/RM). The digital tools necessary for the SVS are supplied by Mezzanine (F6/RM). They also take responsibility for training, technical support and connectivity bundle management (F6/RM). In addition to funding the PoC phase, Vodacom supplies connectivity, the mobile devices that are used by the health officials and a “helpdesk” that provides first line technical support (F6/RM). The Supply Chain Technical Assistance unit (a unit within the NDoH) are responsible for the implementation of the SVS and other operational management duties (F6/RM).

As part of the PoC phase, it is decided to start implementing the SVS within one province and later on within two other provinces in South Africa. The pilot is started and the 605 public health facilities in the Kwazulu-Natal province of South Africa are prepared to implement the solution (F1/EA and F2/KDEV). The pilot is extended by including a further 750 facilities in the Eastern Cape Province and 478 facilities in the Limpopo Province (F1/EA and F2/KDEV).

Workshops are held by members of Mezzanine for the relevant members of the NDoH and members of other ministries of health (MoH) staff (i.e. provincial, regional and district and sub-district health ministry staff) to explain the solution and equip them to be able to do their operational and management duties (F4/GOS and F7/COL). During the workshops, they receive training (F3/KDIF) and are encouraged to lead decision making processes. The workshops have a positive effect on the members that attend it and they start to take interest in the solution (F7/COL). The managers at facility level are chosen as champions for the new initiative (F6/RM). The events map of Stage 1 is given in Figure 7-4.

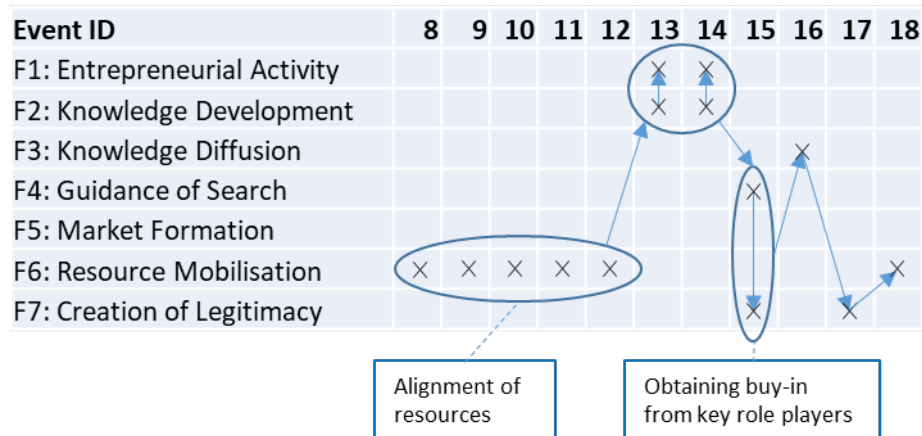


Figure 7-4 Events Map of Stage 1 of Phase 2

At the start of Stage 2, the Treasury approves the usage of the SVS as a mobile solution and it is licenced to the government (F5/MF). The NDoH start to fully finance the SVS (F6/RM) by paying a fixed monthly rate that is determined by the number of facilities that use the solution. In addition to the licencing payment, the government funds the acquisition of a smartphone with a SIM card for each facility, 10 percent buffer stock and a training fee (F6/RM). The training fee involves a “train-the-trainer” approach where members of Mezzanine offer two sessions of training to make the users accustomed to the working of their system. These users are then able to educate other members of staff. This model is applicable since the work force does not remain constant over the duration of the project and therefore if members of staff leave, other members are able to provide training for new members. If deemed necessary by the government, Mezzanine provides additional training and change management support services that cost additional money.

Managers from all the different levels of management are approached to obtain buy-in for the initiative. Mezzanine makes a conscious effort to build relationships with these people of management (F7/COL). They explain in-depth the potential benefit that the solution will offer (F4/GOS). As a result, these managers state that they are interested in the initiative (F7/COL) and

their support as champions for the initiative is secured (F6/RM). This greatly enhances belief in the potential of the initiative and set market objectives. The champions provide very necessary support during the implementation process of the SVS within the various health facilities. The events map of Stage 2 is given in Figure 7-5.

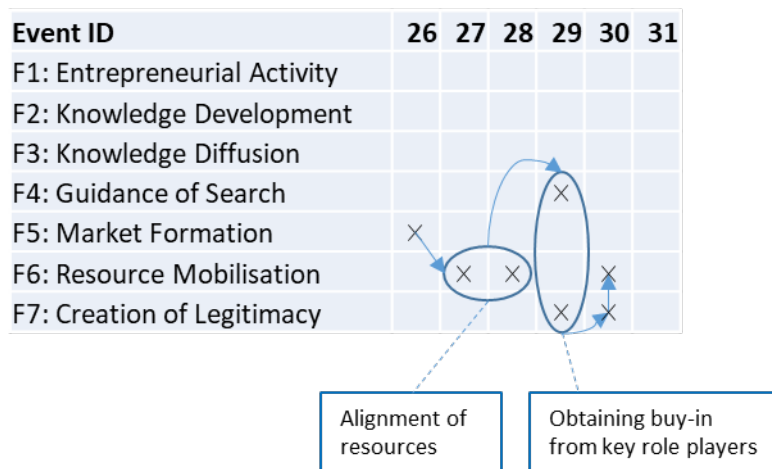


Figure 7-5 Events Map of Stage 2 of Phase 2

At the start of both stages, there are multiple activities focussed on mobilising resources (F6/RM) so that the solution can be implemented among the target audience. This is indicated by the first grouping of events in both events maps (See Figure 7-4 and Figure 7-5). Once the required resources have been acquired, the focus shifts to obtain buy-in from influential members of the target audience. To do this, there is a conscious effort made to form trustworthy relationships (F7/COL) and the initiative is explained in-depth to the key target audience members (F4/GOS). This develops a willingness from many of these key members to be champions advocating the usage of the initiative among their communities, and they become involved as human resources (F6/RM).

7.2.3. Phase 3: Training and Implementation within Facilities

At the start of Stage 1, Mezzanine consults with a field expert who has experience with training operations within the pharmaceutical sector (F6/RM). Members of Mezzanine explain the SVS, the developed app and web interface, and together they develop the training material which results in two manuals – one for the app and one for the web interface (F2/KDEV). Training days are scheduled where various district, sub-district and facility representatives (usually the managers of the different levels) from four districts within a province come together at one venue to receive training as presented by the field expert (F3/KDIF). This is done until all the districts that form part of the PoC phase are covered. The different facility representatives each receive copies of the two manuals plus a poster that can be put up at the facility to explain the process of the solution (F3/KDIF). They are also given the role of champions for the SVS at the facilities where they are involved at (F6/RM).

The solution becomes in use at the facilities (F2/DEV and F3/KDIF). After the solution has been used for some time, it scales at the required amount of health facilities and this reassures the relevant NDoH about the technical viability and feasibility of the solution (F4/GOS and F7/COL). This in turn helps them to strengthen the “business case” for the Treasury for funding which will give the green light for the initiative to be implemented nationally. The events map for Stage 1 is given in Figure 7-6.

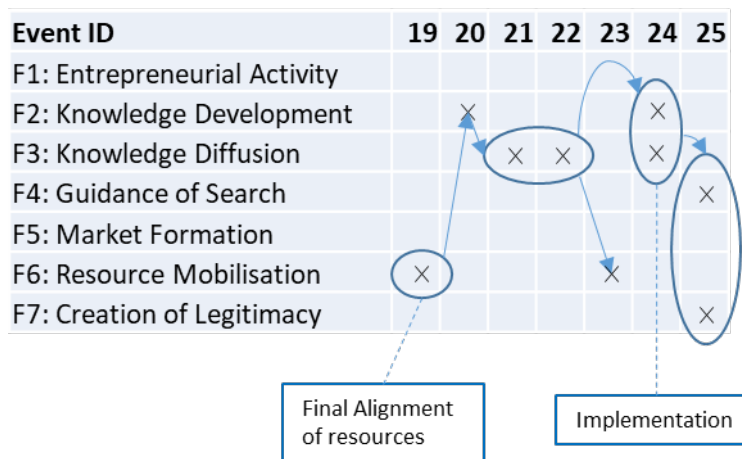


Figure 7-6 Events Map of Stage 1 of Phase 3

Stage 2 starts and the roles of the champions are extended to oversee the change management processes within the facilities that they are responsible for (F6). Similar to the PoC phase, training days are scheduled where various district, sub-district and facility champions from four districts within a province come together at one venue to receive training as presented by the field expert mentioned during the PoC phase (F3/KDIF). This is done until all the districts that form part of the national roll-out are covered and the facility managers have all received training. As a result of the train-the-trainer design approach, the managers are now able to train other users of the system (F6/RM).

After assuming ownership of the SVS (under the licence fees paid to Mezzanine), the NDoH set clear goals for the roll-out of the solution (F4/GOS). It is integrated into the national health system and becomes functional in the public health facilities (F2/KDEV and F3/KDIF). As a result, within the succeeding four months after taking over the licence, the SVS is implemented within an additional 1300 facilities, which brings the total number of facilities using the solution to 3100. The events map for Stage 2 is given in Figure 7-7.

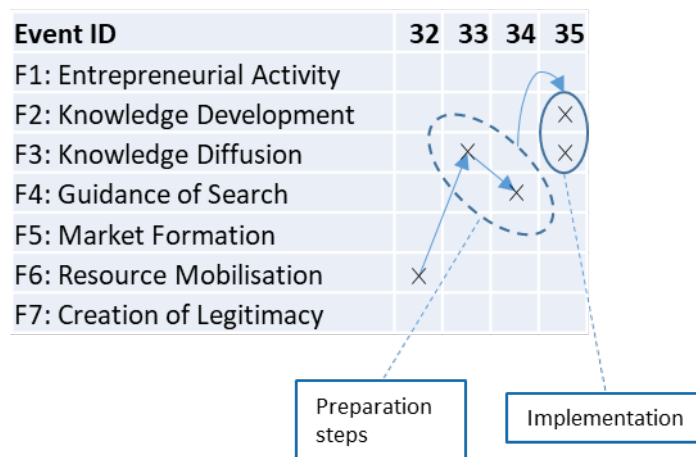


Figure 7-7 Events Map of Stage 2 of Phase 3

At the start of Stage 1, an expert is acquired to assist in developing the training material to train the target audience. This only occurs in Stage 1, because the same material is used in Stage 2 (compare the start of the events maps in Figure 6-8 and Figure 6-9 for Stage 1 and Stage 2 respectively) and therefore it is unique to the first stage. Thereafter members of the target audience receive training (F3/KDIF) and these members are now able to train other members, thus becoming human resources in the system (F6/RM). The target audience start to use the solution within their facilities (F2/KDEV and F3/KDIF).

7.2.4. Phase 4: Shaping and Adaption

The success of the rapid expansion is considered (F2/KDEV) and it is realised that it has unfortunately led to unwanted consequences: It comes to light that change management and training are neglected in order to ensure mass roll-out of the solution. As a result, the solution is poorly adopted within many facilities. Many managers receive training for the second time (F3/KDIF).

As the nationwide implementation phase develops, it is realised that a clear governance structure is absent and as a result, users of the SVS express their confusion (F2/KDEV). A sense of ownership among users, which is crucial for successful uptake of the solution, is lacking. In response to this problem, facility managers are engaged with to explain the benefits of the SVS by enhancing their understanding of the processes and challenges typically faced when managing a medicine supply chain (F3/KDIF and F4/GOS). During this discussion it is uncovered that even though the standard reporting is useful and leads to great improvements regarding stock visibility, it is felt that the data can be used in a new way to build a live dashboard to illustrate the stock in an innovative way. Mezzanine recognises that the integration of the SVS into the standard work protocol of the managers at different levels brings about significant changes. As a result, they adapt the SVS dashboards on their website and software so that it is similar to the monitoring and reporting requirements that the

managers would usually use in their reports (F2/KDEV). This leads to increased usage of the solution. An independent company specialising in supply chain management, is approached to work with the government to help manage the solution from a supply chain perspective (F6/RM). Members of management on national level and this company work together to use the raw data and build a dashboard that generates visual reports of the different facilities, districts and provinces (F2/KDEV). This enables managers to see which facilities and districts submit their reports on the required weekly basis and who do not. The district and sub-district managers are then able to identify problematic facilities and call them to enquire about the lack of reporting.

In addition, a top-down mandate is implemented by the NDoH to enhance the accountability within the relevant structures in order to improve the usage of the solution (F5/MF). Within this mandate the reporting of the facilities is monitored by the district and sub-district managers. The district managers report back to the provincial managers, who in turn report to management at national level. In addition, a cut-off time of 13:00 on a Friday is implemented by which all facilities must have submitted their stock report (F5/MF). This top-down approach plays a big role in overcoming certain change management issues. This improves accountability and results in greater compliance to the adjusted reporting standards.

It is noted that when some facility managers receive low- or no-stock notifications for the facilities that they are responsible for, they initially do not know what to do. This is a consequence of absence of standard operating procedures (SOP). The NDoH develops a comprehensive Standard Operating Procedure (SOP) document (F2/KDEV) to regulate the implementation of the SVS. This document stipulates the requirements and expectations of the users of the solution for all levels within the health system: national, provincial, district, sub-district and lastly the health facilities (F4/GOS). In addition, the SVS app is adapted by integrating it with existing stock ordering software that is already used upstream by ministries of health to make it easier to reorder stock (F2/KDEV).

Some districts do not have staff who fulfil the roles as set out in the SOP document. Where this is the case, theoretically other members of staff are required to fulfil these specific roles. However, some of these members however do not feel that this is fair and state that there is a lack of communication, since they were not initially made aware of the expansion in their roles. In response, the social platform “WhatsApp” is used to create groups where users of the platform can communicate (F3/KDIF). It is primarily used among facility managers and their sub-district and district managers where the latter offer advice, provide important information and support the users under their care. It

is also used as a platform among different facilities to indicate when a specific facility has excess stock that other facilities can use.

It comes to light that a large number of incorrect stock reports are sent to management that contain stock that is not even available at the specific facilities. Unique formulary lists are developed in the app for each health facility to help SVS users to compile proper stock reports of the stock dispensed from their specific facility (F2/KDEV). These lists can be adapted by management in real-time should they require to do so. Furthermore, in some areas pharmacy assistants (PAs) are introduced (F6/RM). This reduces the workload of workers at the facilities. The introduction of PAs results in an improvement of the reporting standard.

The events map of this phase is given in Figure 7-8. Phase 4 signals the first time that the solution is implemented at national level and, since it has not previously been implemented at such a great scale, it is necessary to obtain feedback to understand the performance of the solution. As indicated in Figure 7-8, there are multiple times when feedback is gathered and the system is adjusted to suit the needs of the target audience. These adjustments include renewed training and explanation of the initiative to the target audience (F3/KDIF and F4/GOS), formation of policies by government to ensure usage of the solution (F5/MF), adaption of the model of the initiative (F2/KDEV), and lastly, providing additional training material and communication channels (F3/KDIF).

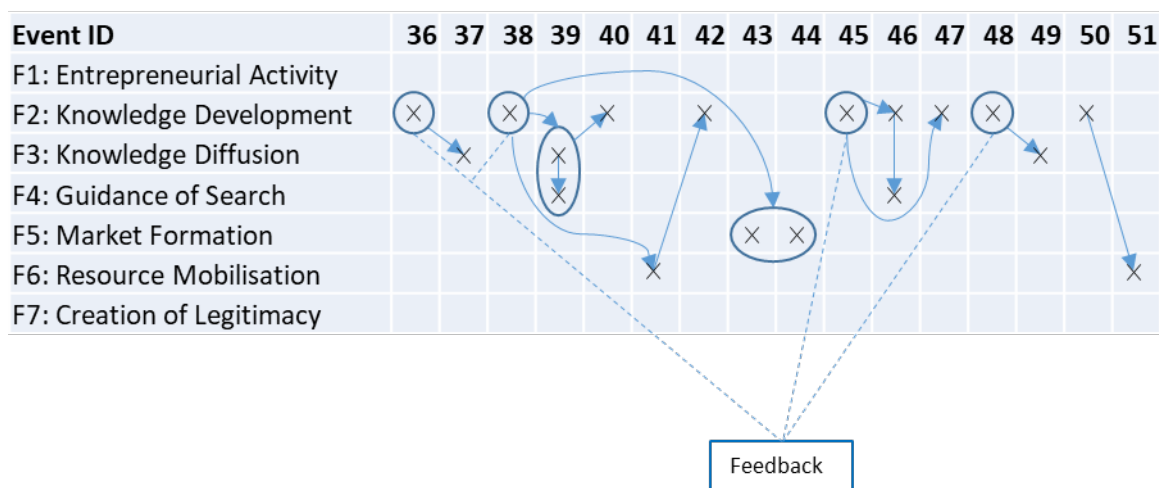


Figure 7-8 Events Map of Phase 4

7.2.5. Phase 5: Post-uptake Feedback

Feedback from users of the SVS is gathered by NDoH representatives after the national roll-out and implementation phase (F2/KDEV) and some users state their dissatisfaction with the solution: They see it as an added task, thus increasing their workload, even though the solution substitute paper-based processes with more agile and faster digital processes, thus lowering their workload. Feedback

from a national level representative (F2/KDEV) state that it was realised how important it is to ensure buy-in from people responsible for the implementation at the various levels in the health sector. Representatives at district level feel that the implementation of the SVS was forced upon them without considering the unique contexts within each district.

In response to the feedback, Mezzanine starts to follow a user-centred design approach that changes the user's perspective of the solution to a pleasant and smooth using experience (F2/KDEV). Renewed group discussions are held to get further feedback (F2/KDEV). A group of PAs (16 people) are interviewed and they all state independently that the SVS mobile app is easy to use. They also state that the SVS is quicker than the previous manual method used to report on stock (F7/COL). Fifteen of the sixteen interviewees view the SVS as a good initiative, in particular because it ensures availability of stock at the various facilities (F7/COL). It is also reported that the solution has had a positive influence on PAs and nursing staff at the healthcare facilities by encouraging them to perform their required tasks (check expiry dates of medicine and use short-dated medicine first) to the best of their ability (F7/COL). They also state that they feel motivated and that "the application is simple, straightforward and easy to use" (GSM Association, 2018) (F7/COL).

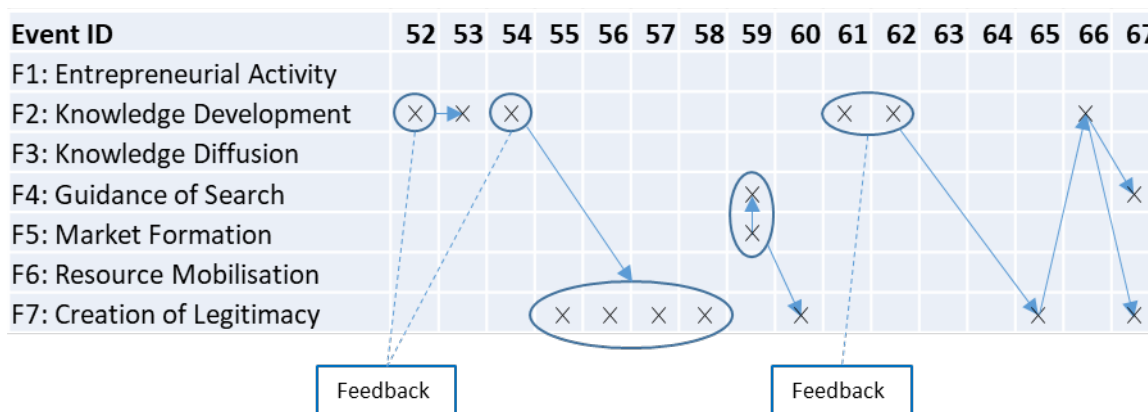
The SVS is added to the ideal clinic assessment list (F5/MF). The ideal clinic assessment list is part of the "Ideal Clinic Programme". This program was started in South Africa in 2013 as an attempt to improve the quality of public healthcare (PHC) services by setting out a list of requirements and key performance indicators (F4/GOS) that PHC is measured against (Fryatt and Hunter, 2015). The addition of the SVS to the list, results in increased compliance among healthcare facilities. It also results in the building of working partnerships between PHC- and pharmaceutical management.

Students from different education facilities start to use the solution in their tertiary studies (F2/KDEV). As part of one such a study, in-depth interviews are held again during 2019 with participating healthcare workers of the SVS program that are involved and/or responsible to manage the stock levels of medicine within primary healthcare facilities, which include pharmacists, assistants and nurses (F2/KDEV). Not all participants of the SVS program can be interviewed as a result of the vast majority of participants. Therefore, the OR Tambo district in the Eastern Cape Province of South Africa is chosen to conduct the interviews and serve as a sample. The objective of this procedure is to gather the participants' experiences and perspectives of the program. The results of the interviews are mixed: Concerns are raised about the effectiveness of the program to address the fundamental problem of stock-outs of medication (such as immunizations and vaccines) in certain facilities in rural areas. It is also time consuming and adds to the already-heavy workload of the workers in facilities

where PAs are not employed. However, the ability to track important information, such as stock availability and expiration dates, and the enablement to redistribute stock levels, are praised (F7/COL). Participants give two primary suggestions to address the aforementioned challenges (F2/KDEV). Firstly, it is suggested that a pharmacist or PA must be employed in each health facility and be tasked to manage medicines. This will allow the nurses to focus their attention on their primary tasks. Secondly, it is desired that district managers should be more involved and assist the health workers, especially with the task of redistributing stock to different facilities. (Iwu *et al.*, 2020)

The researchers who conducted the interviews state that “there is a strong commitment on the side of health workers, ensuring that vaccines and other health commodities are continuously available for their clients (F4/GOS and F7/COL)” (Iwu *et al.*, 2020).

The events map for this phase is given in Figure 7-9. This figure shows by the first grouping of events how initial emphasis of this phase is to obtain feedback after big adjustments to the solution was made in the previous stage (F2/KDEV). Adjustments are made in response to the feedback that have a positive impact of the target audience, resulting in raised advocacy for the solution (F7/COL) (See second grouping on events around creation of legitimacy activities in Figure 7-9). The government adds an assessment list that will increase the usage of the solution within facilities (F5/MF). Researchers start to use the solution in their studies, and in the process obtain more feedback that indicates a positive response towards the solution from the target audience (F2/KDEV and F7/COL).



7.3. Case Conclusion

The insights from Section 7.2 and the events maps from the different stages and phases are used to identify a CLD for each phase that are combined to construct the overall CLD for the SVS case. The causal chains and causal loops present in each phase are indicated with red arrows in each CLD.

This process is started in Phase 1, when the problem of stock-outs of medicine is recognised (F5/MF) and entrepreneurial activities ensue as funding is made available to finance the development of a solution (F1/EA), with the idea that the government will take ownership of the solution once its potential has been proven. The focus shifts towards knowledge development, knowledge diffusion and guidance of search activities: The parties involved in developing the solution collaborate and form partnerships (F3/KDIF), and the solution is developed (F2/KDEV and F4/GOS). The design of the solution is presented to the government (F3/KDIF) and they give their support to the solution (F5/MF). The CLD of Phase 1 is indicated in red in Figure 7-10.

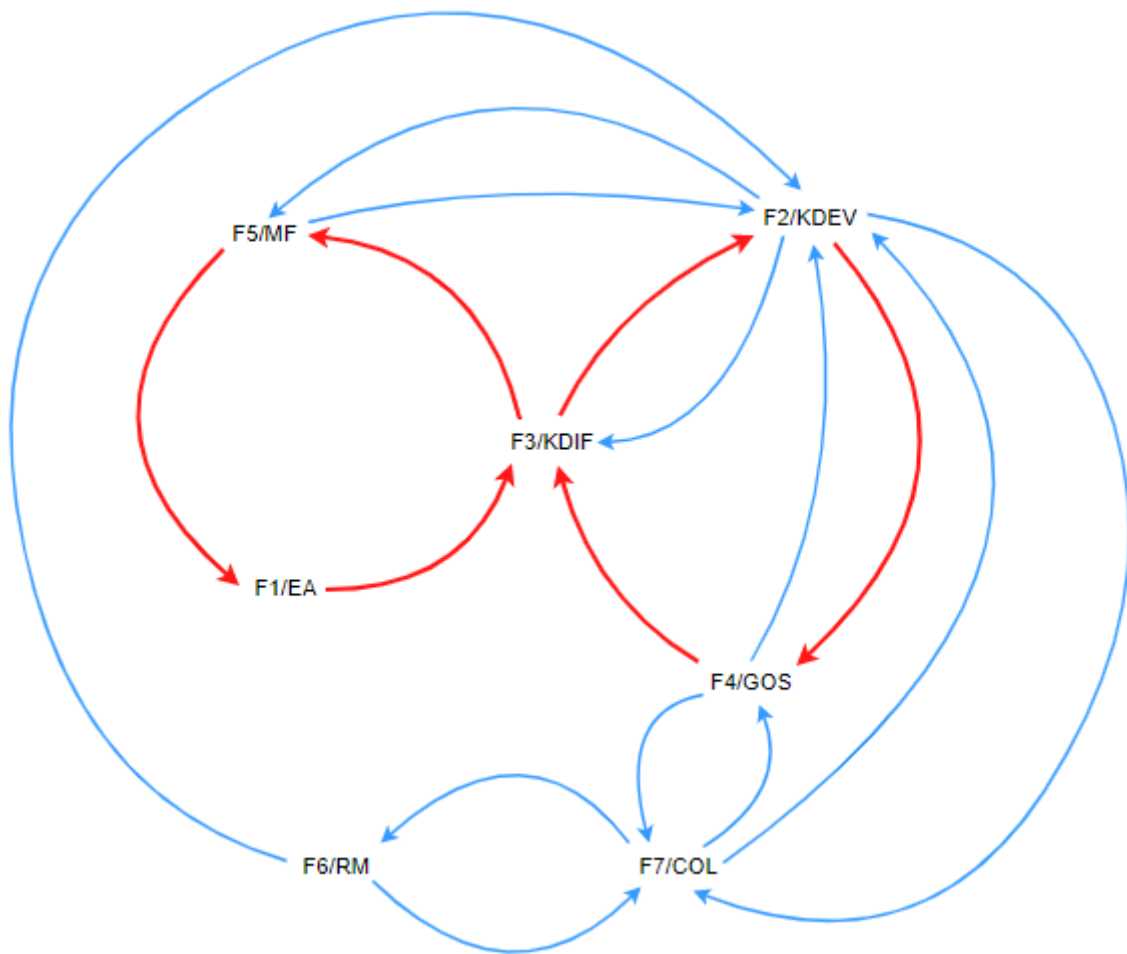


Figure 7-10 Phase 1 - Idea Development

Phase 2 starts with a focus on resource mobilisation activities that will make the implementation of the solution among the target audience possible (F6/RM). Thereafter, the focus shifts towards obtaining buy-in from influential members of the target audience, by consciously making an effort to form trustworthy relationships with these members (F7/GOS), and thereafter communicating the objectives and vision of the solution (F4/GOS). This develops advocacy among the target audience members (F7/COL), which results in their willingness to partake in the solution and become human

resources as they fulfil the role of project champions (F6/RM). The CLD of Phase 2 is shown in Figure 7-11.

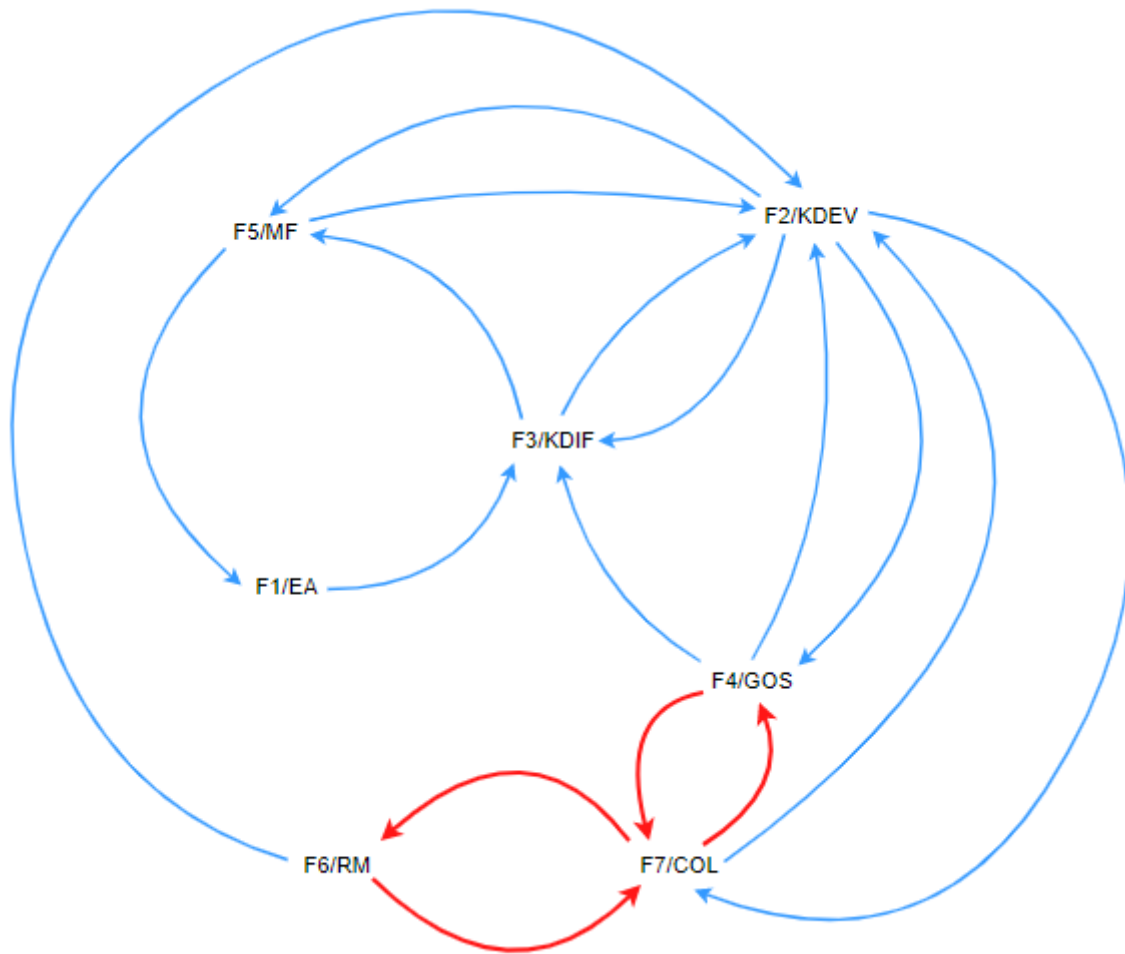


Figure 7-11 Phase 2 - System and Higher-level Management Preparation

The emphasis of Phase 3 is to provide training to the target audience. During Stage 1, the initial focus is on knowledge development activities, as the training material to be used throughout the solution needs to be developed. To assist with this, a field expert consultant becomes part of the solution (F6/RM) and who then develops the material (F2/KDEV). (This only takes place during Stage 1 and the same training material is used in Stage 2.) The focus then shifts to knowledge diffusion activities – training is presented to key members of the target audience (F3/KDIF) who are tasked to train other target audience members of their districts who did not attend the training. The participating members fulfil the role of trainers and champions of the solution (F6/RM). Once training is done, the solution is used (F2/KDEV and F3/KDIF) within the facilities. The CLD of this phase is illustrated in Figure 7-12.

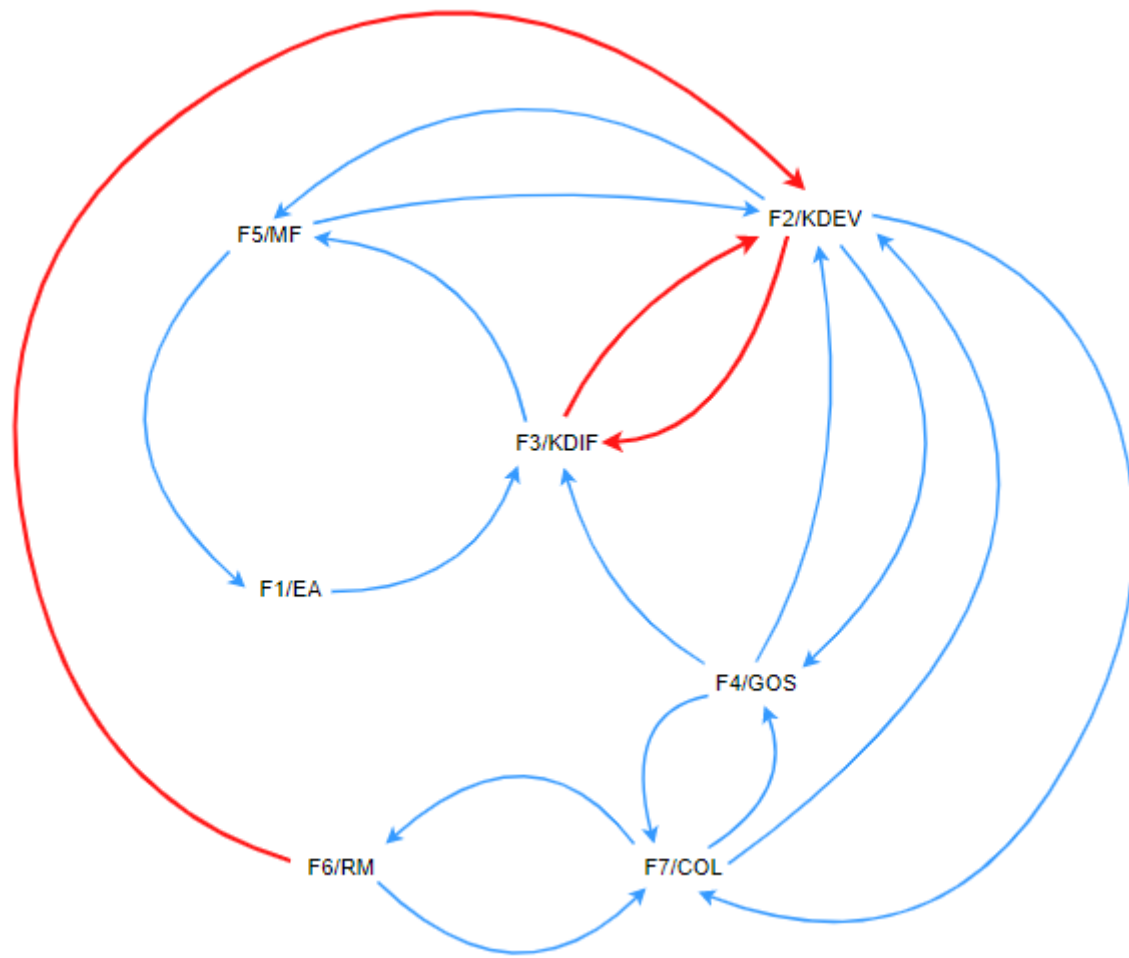


Figure 7-12 Phase 3 - Training and Implementation within Facilities

The focus of Phase 4 is on knowledge development activities by obtaining feedback for the first time since the solution has been implemented across the facilities. Unlike the previous phases, there are not clear causation chains or loops between more than two functions, where one function would start a process that would result in the fulfilment of more than one function. Instead, there are multiple times when feedback is obtained and the solution or system is adjusted accordingly. Once the change is implemented, feedback is obtained again. This process is repeated multiple times, and therefore the only feedback loops are between the obtained feedback (F2/KDEV) and the particular form of adjustment. The adjustments include the following activities: Knowledge development (Adaption of the model of the initiative) (F2/KDEV), knowledge diffusion (Renewed training and establishment of communication channels) (F3/KDIF), guidance of search (Explaining the solution to the target audience) (F4/GOS) and market formation (Development of policies by government to ensure the usage of the solution by the target audience) (F5/MF). The CLD of Phase 4 is shown in Figure 7-13.

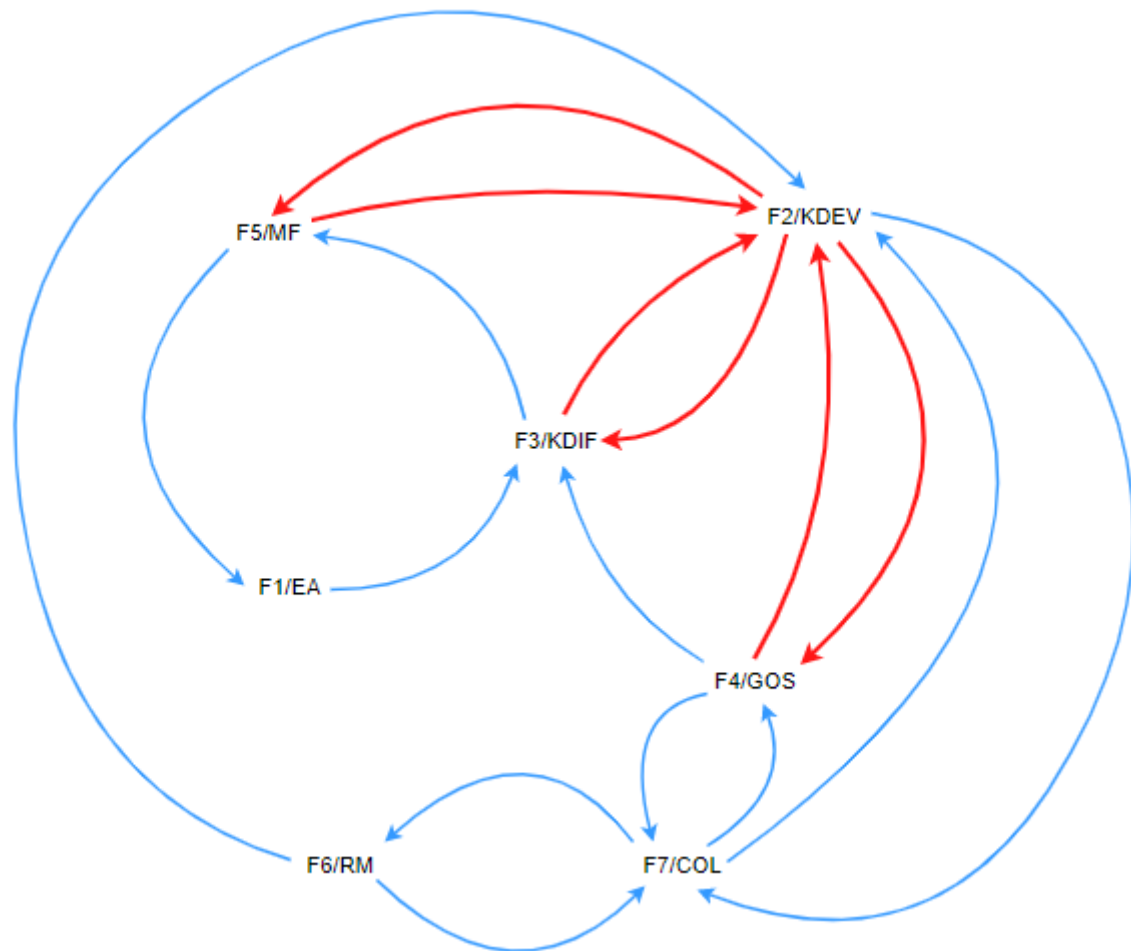


Figure 7-13 Phase 4 – Shaping and Adaption

The initial aim of Phase 5 is to obtain further feedback regarding the solution from the target audience, particularly to understand if the solution is positively received by the target audience, after the multiple adjustments in Phase 4. There is therefore an initial emphasis on knowledge development activities (F2/KDEV). Most of the feedback is very positive, resulting in raising the advocacy regarding the effect of the solution among the target audience and beyond (F7/COL). Arguably as a result thereof, an interest in the solution is raised and some researchers start to use the solution in their studies (F2/KDEV). Their findings are communicated through articles and thesis documents (F4/GOS), which further helps to build legitimacy around the effect of the solution (F7/COL). The CLD of Phase 5 is illustrated in Figure 7-14.

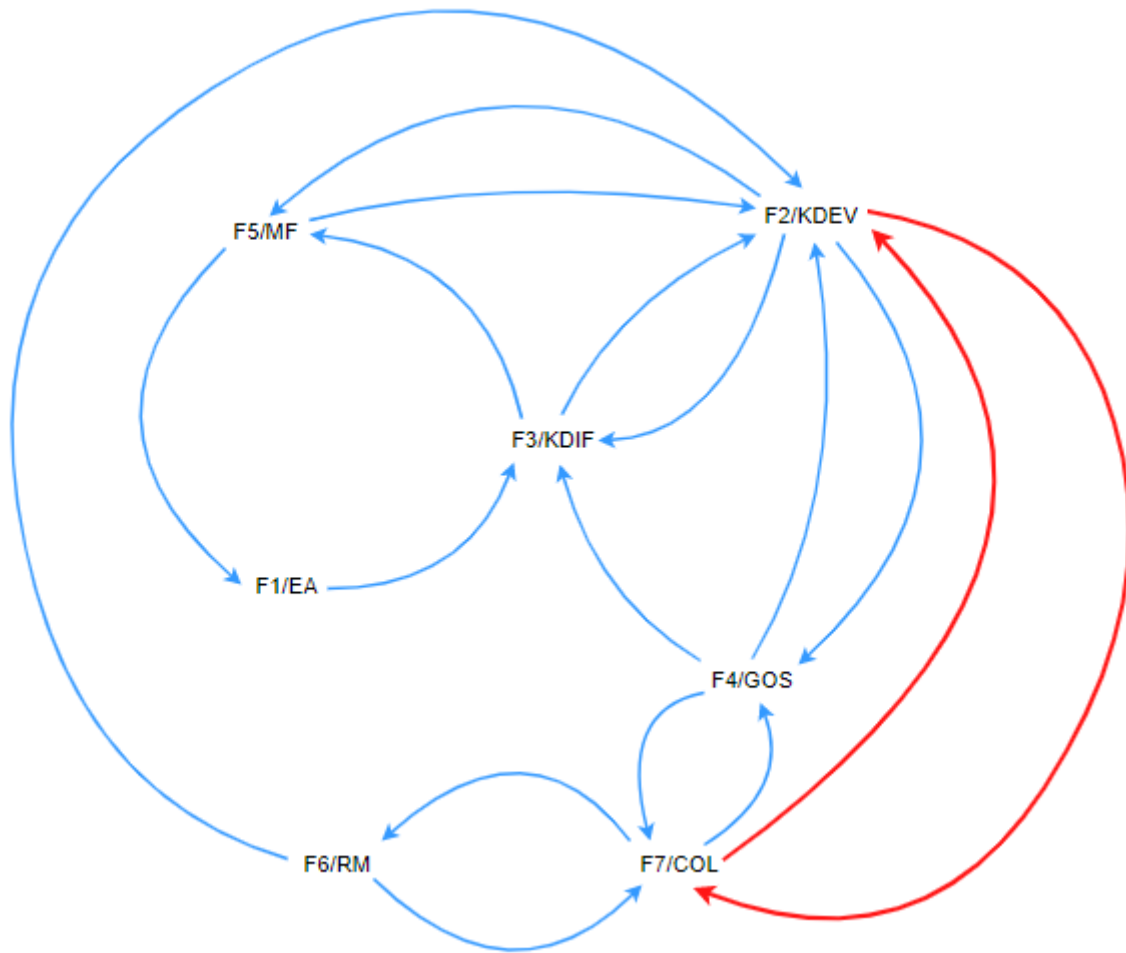


Figure 7-14 Phase 5 - Post-uptake Feedback

In addition to the functional dynamics, the cumulative fulfilment of all 67 events are mapped across the five phases to uncover the trend pattern of the case (See Figure 7-15). Similar to the ICT4RED case, the same phases (Phases 2 and 3) occur at different stages during the case and the event IDs do not follow sequentially on one another. The events are therefore grouped together according to the phase that they form part of. The pie charts in Figure 7-15 show what functions were prominent in each of the phases. Initially in Phase 1, there is an even spread of events across market formation activities (F5/MF), knowledge development activities (F2/KDEV), knowledge diffusion activities (F3/KDIF), entrepreneurial activities (F1/EA) and guidance of search activities (F4/GOS). In Phase 2, the same activities remain present, but resource mobilisation activities (F6/RM) and creation of legitimacy activities (F7/COL) not only become present, but become the emphasis of this phase. Because of the big emphasis on training in Phase 3, knowledge development and diffusion activities (F2/KDEV and F3/KDIF) are prominent. In Phases 4 and 5, there is a big focus on knowledge development activities (F2/KDEV) as feedback is gathered. Creation of legitimacy activities increase in Phase 5, as advocacy regarding the solution rises once the positive effect thereof is realised.

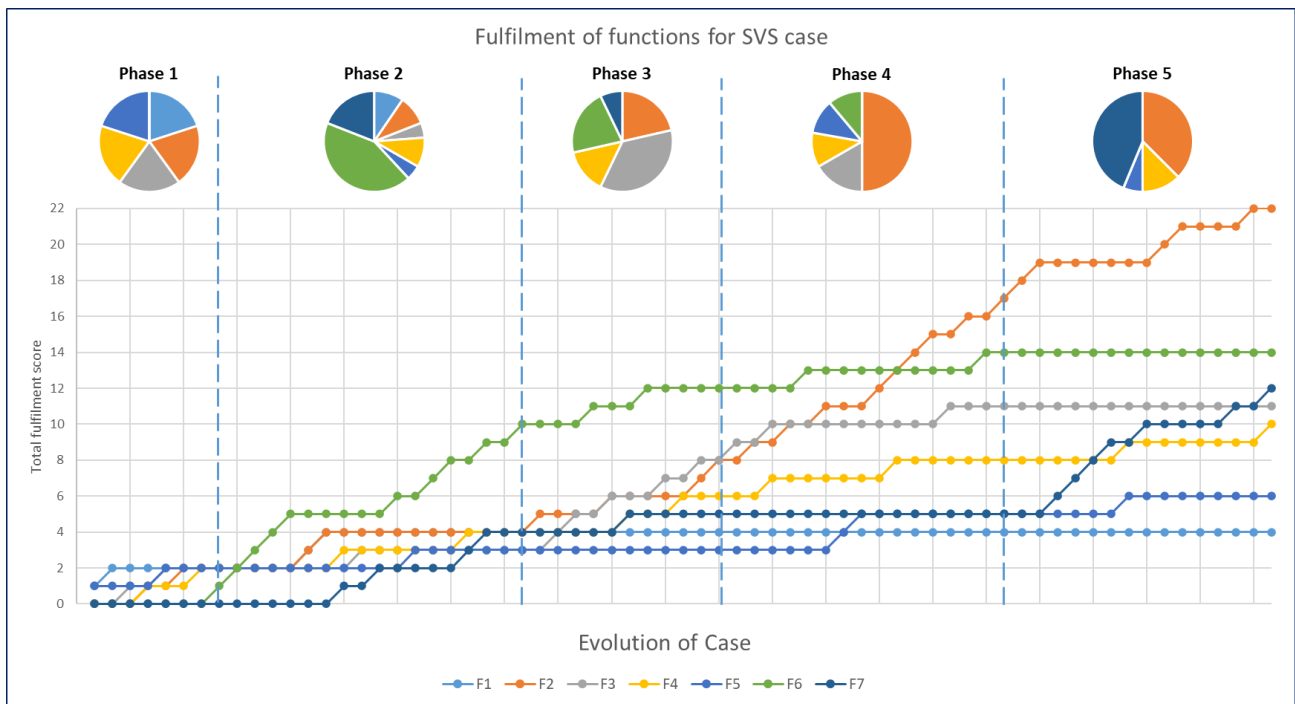


Figure 7-15 Trend Pattern of SVS Case

7.4. Chapter Summary

The work in this chapter focusses on the analysis of the third case study – the SVS case – according to the EHA method explained in Section 2.1 and 4.1. The first section (Section 7.1) provides the background of the case and how the SVS solution came about against the backdrop of the problem of frequent stock-outs of important medication in South African clinics. Section 7.2 discusses the data collection to identify important events and the database construction thereafter. Within this section, the case is divided into five phases and the events are mapped to the different system functions (using events maps) to identify the interaction patterns present in the case. Conclusions regarding the case are given in Section 7.3 and the overall CLD for the case is given. The trend pattern for the case is also provided and discussed in this section.

Chapter 8

Case Synthesis and Final CLD

In this chapter, the findings of the cases are synthesised to construct a final CLD that represents the causal narrative that shows how the system functions work together during different phases across the three cases to identify core dynamics found within I4IDS. This is done during the conclusion of this chapter in Section 8.7. To do this however, the different phases across the three case studies are synthesised in Section 8.1 to identify communal phases. Five phases are identified that are discussed in Sections 8.2-8.6, followed by the construction of a CLD of each phase, that illustrates the narrative for the specific phase.

8.1. Phase Synthesis

In accordance with the EHA method explained in Section 2.1, the final step of this method is to synthesise the outcome of the different cases to present a general insight into the functional dynamics that are present among the cases, and the way that they develop in the form of CLDs. Each of the CLDs are then used to construct a final CLD that illustrates the development of the combined I4IDS across the three cases.

As explained in Section 4.1.5, to gather an insight into the general dynamics across the cases, the different phases identified across the three cases analysed in Chapter 5, Chapter 6 and Chapter 7 are compared to identify the similar phases among them – using the objectives, desired outcomes and example activities of each phase. Therefore, to start this process, the phases of each case are summarised according to their objectives, outcomes, and key activities. The results of this summary are given in Table 8-1 for Mafarafara, Table 8-2 for ICT4RED, and Table 8-3 for SVS. The objectives, outcomes and key activities in the tables are used to match the phases in each case to similar phases of the other cases, and the result thereof is illustrated in Figure 8-1, where it shows in which cases each of the identified phases are present. The final phase for Mafarafara is not considered in the synthesis process, since the project has stalled and there are no causal chains that come from the phase that will result in feedback loops or contribute to a CLD.

Table 8-1 Summary of Phases of Mafarafara case

Phase	Aim/Outcome of the phase	Key Activities
Phase 1: Pre-engagement project preparation phase	In this phase, the primary focus is on the preparation for the project. Contact with the target audience is not made, except at the very end of the phase, once all the necessary technology and training material has been developed. This phase therefore outlines all the steps that are taken before the implementation of the project among the target audience can take place. Once this has been done, contact is made with the target audience to explain the project to obtain their participation.	<ul style="list-style-type: none"> - Development of the technology to be implemented - Conducting research to identify a suitable target audience - Obtaining ethical clearance - Developing training material - Conducting a pilot study - Explanation of the project to the target audience - Obtain approval from target audience to carry out the project
Phase 2: Obtaining buy-in from target audience	The primary objective is to obtain buy-in from the target audience to participate in the project, since only approval in principle has been given by the target audience to the project team to carry out the project. The big focus of the phase is to introduce the project in person and build relationships with the target audience. The project is not yet started or implemented among the target audience.	<ul style="list-style-type: none"> - Introduce/explain project to target audience - Build trustworthy relationships with influential leaders among target audience
Phase 3: Prior Research and installation	The focus of this phase is primarily to install the technology to be used in the project. Some prior additional research is done to refine the installation of the technology.	<ul style="list-style-type: none"> - Research to improve implementation of technology - Installation of technology
Phase 4: Training and usage	The aim of this phase is to provide training for the target audience about the use of the technology and to further develop the content of the technology (project) to suit their needs. This is the first time that training is offered, and the target audience start to use the technology.	<ul style="list-style-type: none"> - Training - Build advocacy and convince certain target audience members that are not yet fully convinced or fully participating in the project
Phase 5: Project shaping and adjustments	This phase takes place after the project has already been implemented for some time already. The main objective of this phase is to gather feedback from the target audience and adjust and improve the technology/project accordingly to improve the probability of continued usage.	<ul style="list-style-type: none"> - Gather feedback from target audience - Improve technology by adjusting it according to needs of target audience - Continued effort to build advocacy surrounding the project
Phase 6: Monitoring visits	Similar to the previous phase, the primary objective is to gather feedback and adjust the system. The difference is that by now, the focus is more on monitoring and maintaining the system, instead of primarily seeking how to improve it.	<ul style="list-style-type: none"> - Gather feedback from target audience - Monitor participation of target audience in the project - Continued effort to build advocacy surrounding the project
Phase 7: Reinstall technology	The objective of the phase is simply to reinstall the technology after maintenance is done.	<ul style="list-style-type: none"> - Reinstall technology and renewed training - Improve technology by adjusting it according to needs of target audience
Phase 8: Unplanned stalling of project	Unplanned phase after technology becomes unusable due to unforeseen circumstances. Feedback obtained to see how target audience reacts after technology becomes unusable.	<ul style="list-style-type: none"> - Gather feedback

Table 8-2 Summary of Phases of ICT4RED Case

Phase	Aim/Outcome of the phase	Key Activities
Phase 1: Research and Preparation	The primary focus of this phase is on research and development of an implementation strategy in the form of an implementation model. Most of the research is aimed at developing the implementation model. Based on the model, the research team tasked to drive the initiative is formed. No contact is made with the target audience yet.	<ul style="list-style-type: none"> - Research - Obtaining ethical clearance - Development of an implementation strategy in the form of an implementation model - Formation of the team tasked to drive the initiative - Acquiring of technology to be used in the initiative
Phase 2: Obtaining buy-in from target audience	Three iterations of this phase occur. Primarily the objective of these phases is to obtain buy-in from various members of the target audience. During the second and third iterations, human resources are raised up as a result of the buy-in obtained. This phase signals the first time that the target audience is engaged with.	<ul style="list-style-type: none"> - Explain initiative to key role players - Build trustworthy relationships with influential leaders among target audience - Obtain the approval, buy-in and support from the necessary authorities to implement the initiative within schools - Raising up of human resources because of buy-in obtained
Phase 3: Preparation and Training	Three iterations of this phase occur. The objective of this phase is to provide training to key members of the target audience to equip them with the required skills to implement the initiative among other members of the target audience. In the process, the key members are raised up as human resources. This is one of the final preparation steps before the initiative is implemented among the schools.	<ul style="list-style-type: none"> - Development of training material - Training activities - Implementation of incentives to motivate target audience to participate in training - Raising up human resources through training to assist with further implementation
Phase 4: Implementation, Usage and Feedback	Three iterations of this phase occur, and the feedback from the iteration is used to inform and improve the next. The primary objective of this phase is to implement the technology among the school members of the target audience (schools and learners) and gather feedback to improve the initiative for the next phase of implementation among other schools. This phase is the first time that the usage of the technology is implemented within the schools and the target audience start to use it consistently. It is therefore viewed to be the first time where the initiative is implemented within the group of the target audience towards whom the initiative is specifically aimed.	<ul style="list-style-type: none"> - Providing technology and installing supporting infrastructure - Learning-by-using - Gathering feedback and adaption of implementation model - Evolve, adapt, and improve learning material and technology - Formation of trustworthy relationships among different members of the target audience
Phase 5: Project Disengagement and Handover	The objective of this phase is to firstly prepare the system for the handover of the initiative and then eventually to handover to key personnel who will take over ownership responsibilities of the initiative. This is the last phase of the initiative and signals the disengagement of the implementation team from the initiative.	<ul style="list-style-type: none"> - Communicate outcomes of the initiative to the public - Build legitimacy around the positive effect of the initiative - Involvement of governmental authorities to use resources and assist with the further implementation of the initiative in other areas - Initiative is used in various studies by researchers

Table 8-3 Summary of Phases of SVS Case

Phases	Aim/Outcome of the phase	Key Activities
Phase 1: Idea Development	The primary aim of this phase is to establish partnerships between key role players and actors to develop a solution. This phase focusses on activities and preparation steps before the solution gets implemented. Collaboration, and communication of vision and expectations among the actors take place, which result in the first conceptualisation of the proposed solution. At this stage, the development of the solution is still in its infancy. It is also important to note that the target audience has not been engaged with in this stage.	<ul style="list-style-type: none"> - Obtaining funding - Establishment of business model for solution - Collaboration, vision explanation and communication of expectations and targets - Formation of partnerships among solution developers and the implementation team, governmental authorities, and other key stakeholders
Phase 2: System and Higher-Level Management Preparation	This phase is the first time when the solution is implemented within high-level settings among the target audience. The focus of the phase is on the alignment of resources and developing buy-in from key actors, particularly among the high-level target audience members. Training takes place but is only focused on a small and select group of the target audience to improve buy-in and enhance understanding of the way the solution works. Training activities aimed towards the practical equipping of target audience members and to familiarise them with the solution. Implementation of the solution at large doesn't take place in this phase.	<ul style="list-style-type: none"> - Generate and align human, financial, and technological resources - Implementation of solution among the target audience settings - Workshops and training activities for key members (high authority personnel) among target audience - Build trustworthy relationships between target audience and implementation team - Raise up human resources from among target audience - Develop advocacy regarding the solution among target audience members
Phase 3: Training and Implementation within Facilities	The focus of the phase is two-fold. First, focus is on preparation before the solution is implemented: Training materials are developed, training is given and roles are given to target audience members. Second, focus moves to roll out the initiative and it becomes functional across all areas.	<ul style="list-style-type: none"> - Develop training material - Providing training for all members of the target audience - Mass implementation of solution at ground level across all target areas - Raise up members of the target audience as human resources
Phase 4: Shaping and Adaption	Within this phase, the solution has been implemented among the target audience for at least some time to evaluate the outcomes. The focus of this phase is to evaluate the effect of the solution and to make the necessary adjustments to the solution and its processes to ensure that the solution functions properly and continues to be used. The solution is refined and some additions are made to improve the solution.	<ul style="list-style-type: none"> - Evaluate outcomes of the solution - Gathering feedback about the solution from some members of the target audience - Adjusting the solution according to the needs of the target audience - Renewed training - Getting additional resources to improve solution and its usage - Formation of policies by government to improve uptake of solution
Phase 5: Post-uptake Feedback	The focus of this phase is to obtain feedback from the target audience about the solution, and particularly with regards to the refinements, adaptations and additions that were made in the previous phase. This phase is different from the previous one, because iterations were made previously, and it is now the second time where feedback is gathered from the target audience. Often times feedback is gathered and based on it, iterations are made to the system.	<ul style="list-style-type: none"> - Obtaining feedback from members of the target audience about the solution. - Adapting the design of the solution based on feedback - Formation of policies by government to improve uptake of solution - Solution is used in various studies by researchers

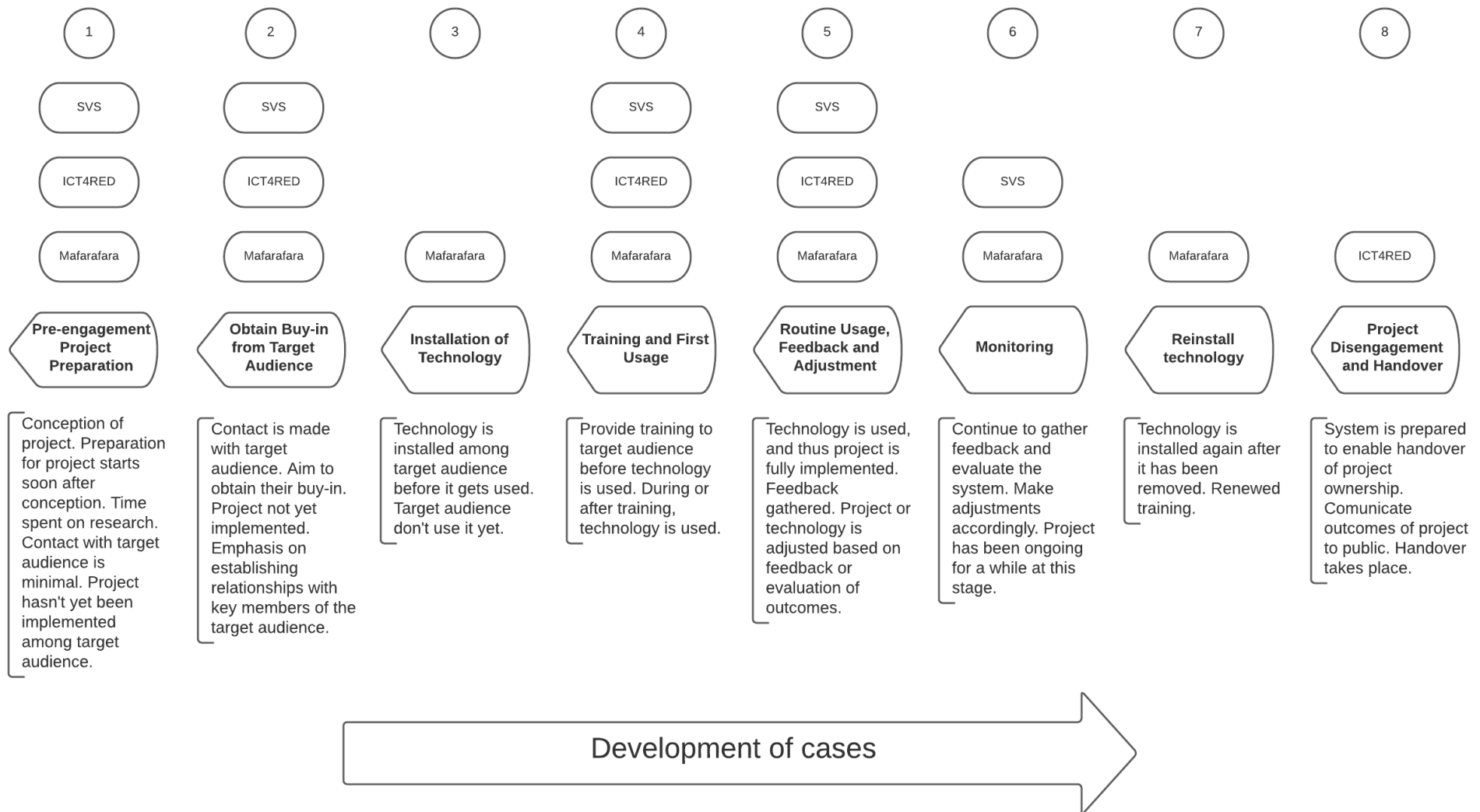


Figure 8-1 Matching of similar phases across all three case studies

Across the eight phases, five general phases are identified that are similar and present in at least two of the cases. A sixth phase is also identified that is only present in the ICT4RED case, but it is also the only case that had evolved up to the point where disengagement took place. It can be expected that the other cases will also develop up to that point and it is therefore included. The six similar phases are shown in Figure 8-2 and Figure 8-3. The phases in blue in Figure 8-2 show the general phases, and Figure 8-3 points out in detail which phases in each of the cases make up each of the general phases.

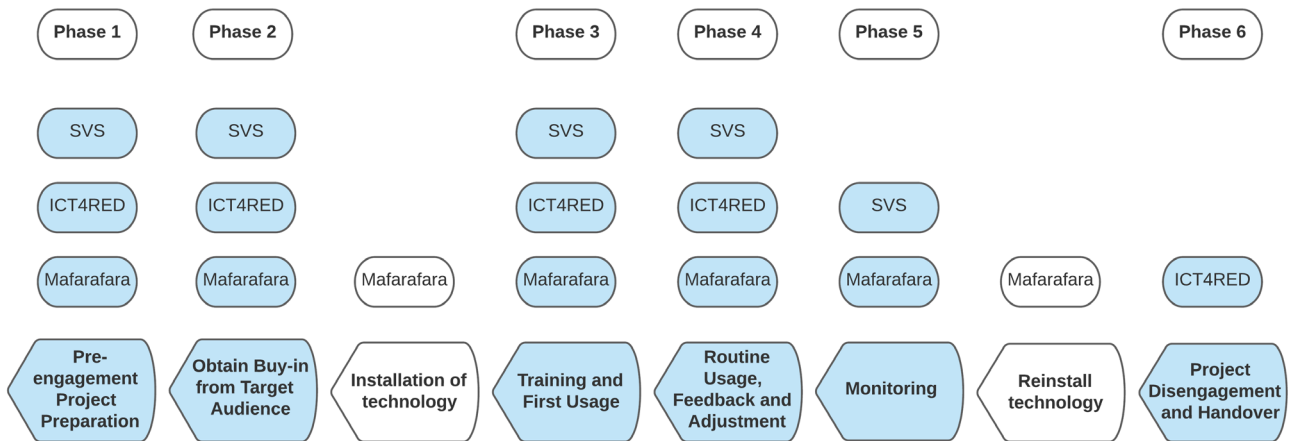


Figure 8-2 Six distinct phases after synthesis

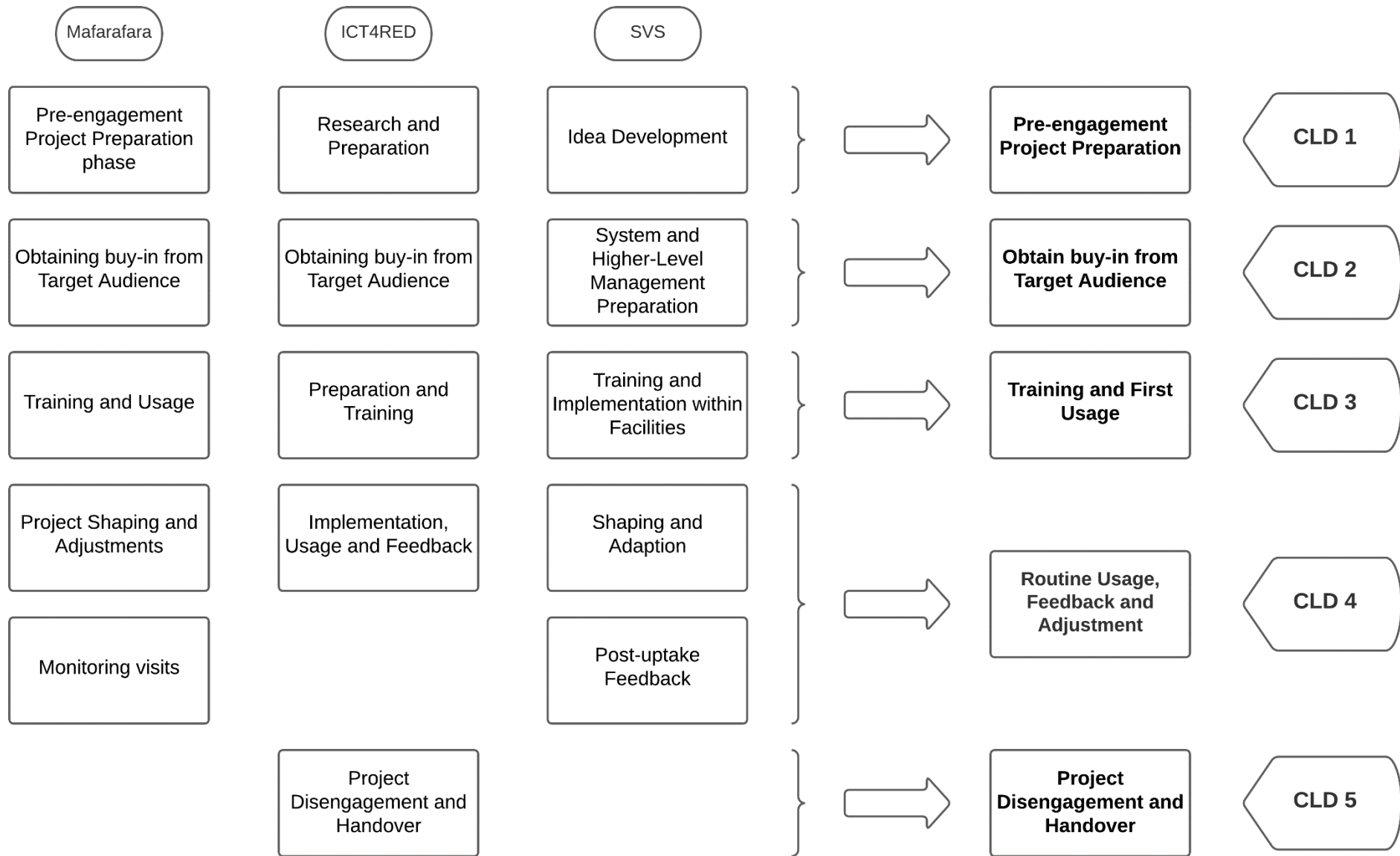


Figure 8-3 Similar phases across the three cases

8.2. Pre-engagement Project Preparation

In the Mafarafara case, there is a big emphasis on research and preparation activities. These include the following: The technology is developed and then tested, research is done to identify the suitable target audience and training material and ethical clearance are obtained (F2/KDEV). Thereafter, contact is briefly made with a representative from the target audience to introduce the project (F3/KDIF), communicate the vision and expectations, and raise awareness and belief regarding the project among the target audience (F4/GOS). This results in the willingness of the target audience to participate in the project on a preliminary basis (F1/EA), and the project is sanctioned by a leader among the target audience (F7/COL).

Similar to the phase in the Mafarafara case, there is a big emphasis on research activities at the start of the ICT4RED case: Ethical clearance is obtained, literature reviews are done and an implementation model is developed (F2/KDEV). Based on the findings and subsequent needs, a core team is assembled that will be responsible for the implementation of the initiative (F6/RM). Once more research is done to identify the suitable technology (F2/KDEV) that is then acquired (F6/RM).

The start of the SVS case is somewhat different to the Mafarafara and ICT4RED cases. The project is started at the backdrop of the stock-out problem among the target community as a proposition to a solution for the stock-out. It is officially started as a company is willing to subsidise a solution (F5/MF) and makes funding available (F1/EA). Collaboration between private entities and the government take place and a partnership is formed between them (F3/KDIF). Once this is done, preparation is done, and a proposed structure of the solution is developed (F2/KDEV and F4/GOS). The design is proposed to the government (F3/KDIF) and support is given (F5/MF), although it is decided that the implementation will take place in stages. The first stage will serve as a pilot (F2/KDEV) to prove the efficacy of the solution to government (F4/GOS).

Conclusion

In comparison between the three different phases of each case, there are not specific repetitions of fulfilment of functions across the three cases, but there is a shared aim of preparing the system before the actual solution or technology or project is implemented. This develops in a different way in each case, but the focal point is present in all three: There is a big emphasis on research and development, particularly in the Mafarafara and ICT4RED cases. In the SVS case, this is present, but it forms a smaller part of the actual activities in the phase. With research and development forming the central part, each case gives examples of how this influences the rest of the system.

The start of the CLD is derived from the initial development in the SVS case where the stock-out problem creates a need for a solution and a company is willing to subsidise this solution. Thus, a market is created (F5/MF) and funding to finance the project is provided (F1/EA). Once funding is provided, collaboration between the different stakeholders can take place and partnerships are formed (F3/KDIF). Once partnerships are formed, it enables the different stakeholder groups to take ownership of the activities that they are responsible for. Since the project is in the preparation phase, one would expect that there would be a group among the stakeholders tasked to develop the structure of the project before it can be implemented among the target audience. A big part of this, is research and development, and therefore activities aimed towards this are started: Research takes place and the implementation structure of the project is developed (F2/KDEV). This takes place in all three cases.

In turn, the research activities can result in the formation of specific project teams to drive certain parts of the project (F6/RM) as is illustrated in the ICT4RED case. These teams become human resources and further take ownership of specific areas of the project and do further research and development (F2/KDEV).

The remainder of the CLD primarily derived from the Mafarafara case. Once the research and development activities draw to a close, contact is made with the target audience (F3/KDIF) and the project is explained to them to hear if they are willing to collaborate (F4/GOS). This is done to find out if they are willing to participate, and not to “sell” the project to them. If the target audience is unwilling to participate, it saves the implementation team a lot of time and they can move on to other target audience groups that they have identified to potentially be part of the project. The explanation of the project leads to the willingness from the target audience to participate, and the project is approved (F7/COL). The CLD containing the core dynamics within the pre-engagement project preparation phases across the three cases is illustrated in Figure 8-4.

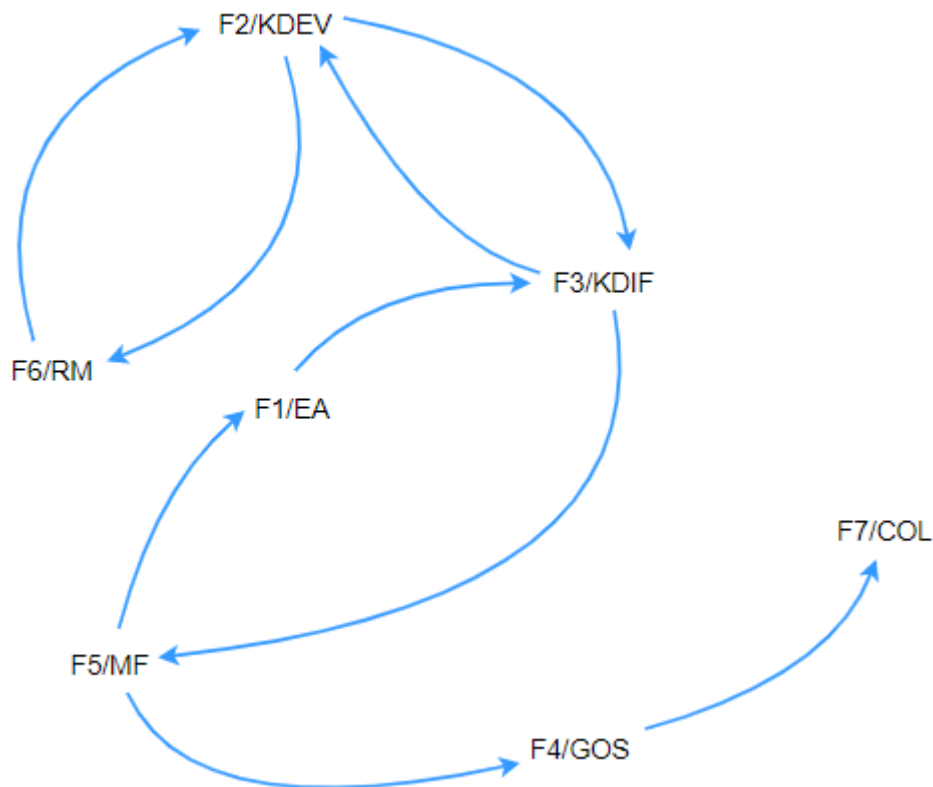


Figure 8-4 Pre-engagement Project Preparation CLD

8.3. Obtain Buy-in from Target Audience

In the Mafarafara case, the project team focuses on building trustworthy relationships (F7/COL) with specific target audience members and then introducing the project and its desired outcomes (F4/GOS). This pattern occurs twice, firstly with the project champion (part of the target audience) and then the local leader of the target audience and buy-in obtained. Thereafter, engagement takes place with the broader target audience, but this time the project and its desired outcomes are firstly explained (F4/GOS) and then there is a focus on building trustworthy relationships (F7/COL) to obtain buy-in.

In the ICT4RED case, there are three instances where there is a big focus on obtaining buy-in from the target audience. In each of these, the initiative is explained (F4/GOS) and then buy-in is obtained from different groups among the target audience (F7/COL). It is important to note the sequence in which the groups are approached. It always starts with the governmental authorities involved. Then, leaders in the target audience (school leadership group) are approached. In one instance, a leader among the village is also consulted and his buy-in is also obtained. In one of the three instances, when the government is approached and their buy-in is obtained, they themselves further contribute to the project by introducing a policy (F5/MF) to ensure that local governmental officials assist the team with the project (F6/RM). In one of the other instances, once governmental buy-in is obtained, a

partnership is established with a local group after the project is explained to them (F4/GOS) and they also assist the team driving the initiative (F6/RM).

Similar to the ICT4RED case, the focus on obtaining buy-in from target audience members in the SVS case occurs more than once across two different instances: Once when the PoC stage starts, and the next when the national implementation of the solution begins. The PoC stage starts with the alignment of various resources (F6/RM), before the solution is implemented as a pilot project (F1/EA and F2/KDEV). Effort is made to obtain buy-in from various members of the health ministry staff in the form of workshops where the solution is explained (F4/GOS) and their buy-in is obtained (F7/COL). As part of the workshops, training is presented (F3/KDIF) with the goal to equip some members of the target audience as managers, but primarily to enhance their understanding of the solution so that they will be willing and encouraged to take part. This indeed happens and they take interest in the solution (F7/COL). They are chosen as champions for the initiative.

In the national implementation stage, the treasury approves the solution, and the necessary resources are gathered to enable the nationwide implementation of the solution (F6/RM). Next, managers from different levels are approached, and a conscious effort is made to build trustworthy relationships between the implementors of the solution and these managers (F7/COL). Thereafter, the solution is explained extensively (F4/GOS), that in turn results in the buy-in from the various managers (F7/COL). These managers take up the positions of champions of the solution (F6/RM).

When comparing the three cases, it is important to note that unlike the Mafarafara and ICT4RED cases, the attempt to obtain buy-in from the target audience in the SVS case is quite brief and is primarily focussed on the management personnel within the target audience. It makes sense that higher-level governmental buy-in from the leaders in the NDoH is not necessary in the sense that they have to approve the solution, since the NDoH is one of the entities driving the solution and are thus for the most part already involved. However, there is a contrast between the Mafarafara case and the SVS case in particular: There is a focus to obtain buy-in from the general members of the target audience who do not form part of the management team in the Mafarafara case, but not in the SVS case. This may point to one of the things that should have been part of this case but was neglected. This idea is strengthened by occurrences during other phases later in the SVS case, where it recognised that change management processes have been neglected in favour of rapid implementation (specifically during the PoC stage), resulting in poor adoption of the solution in facilities and a general confusion among the target audience regarding the solution.

Conclusion

In comparing the different cases, there is a general dynamic in all three cases that form that basis of the CLD, and to which most of the attention in the phases are aimed towards. This dynamic refers to the process where the project is explained to the target audience, along with the vision and desired outcomes thereof, and then buy-in is obtained from the target audience. This dynamic occurs repeatedly within the different phases, and usually starts with the members of the target audience of the highest authority and ends with the general members of the target audience. This dynamic can also be slightly different according to the need of the system, as is seen in the Mafarafara case, where the establishment of trustworthy relationships first takes place before the project is explained. However, it constantly follows the pattern mentioned earlier where the project is explained and buy-in is obtained, but the sequence thereof may differ. As mentioned, this is the general dynamic within this CLD, and it forms the basis, but there are also various other dynamics that occur.

The start of the CLD is derived from the SVS case, where the alignment of resources takes place (F6/RM). With the necessary resources made available, contact can be made with the target audience to obtain their buy-in. This signals the start of the previously mentioned buy-in dynamic. As is seen in the Mafarafara case particularly, it may be necessary to first establish trustworthy relationships with key members of the target audience (F7/COL). Thereafter, the project can be explained and the vision and desired outcomes can be communicated (F4/GOS). The context of this differs, but in the Mafarafara and SVS cases workshops are held to explain the project and at the workshop while the project was introduced, forms of training are presented (F3/KDIF). However, later on in both cases there are phases specifically aimed at training, and this is seen simply as a result of the explanation of the project and the context in which it takes place in order to obtain buy-in. Once the project is explained and the vision and desired outcomes are communicated, it results in obtaining buy-in from the target audience as they agree to partake in the project (F7/COL). The results of obtaining their buy-in manifests in different ways, but as is seen in the ICT4RED and SVS cases, it results in the generation of resources within the system (F6/RM), mostly in the form of human resources. There are different ways in how the resources are generated, and within the two mentioned cases, it took place in three ways.

First, once buy-in is established, specific members of the target audience are willing or tasked to assist the project team with the project. Thus, the generated buy-in (F7/COL) simply results in members of the target audience assisting the project team (F6/RM). Second, once buy-in is established from government (or other authorities), they develop policies (F5/MF) that members of the target audience must adhere to so that they can assist or form part of the project team (F6/RM). Third, they incentivise

programs (F4/GOS), so that persons who are not initially part of the project, can join the project team as assistants (F6/RM). The core dynamics of the phases across the three cases focussing on obtaining buy-in from the target audience are illustrated in the CLD in Figure 8-5.

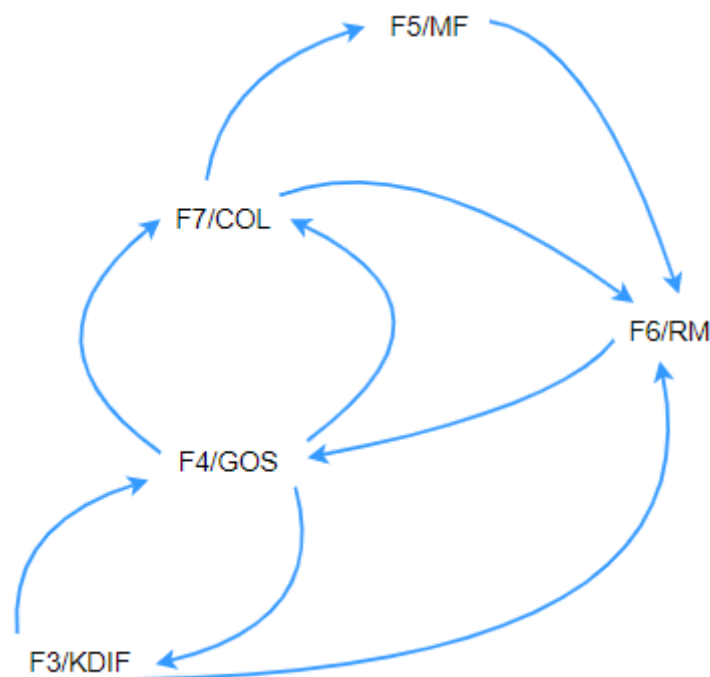


Figure 8-5 Obtain Buy-in from Target Audience CLD

8.4. Training and First Usage

In the Mafarafara case, the phase starts with the implementation team strengthening the previously established trustworthy relationships with members of the target audience: The village chief is visited and updated about the progress of the project (F4/GOS and F7/COL). Thereafter, the target audience is gathered (F3/KDIF) and the project is again explained, and particular emphasis is placed on the fact that everyone is welcome to participate (F4/GOS). Thereafter, various training activities ensue (F3/KDIF). Worth mentioning is that the target audience start to use the technology and learning-by-using takes place (F3/KDIF). Other members of the target audience also receive training to assist the ERW (F3/KDIF). They take up the roles as assistants, and become functional in the system as human resources (F6/RM).

In the ICT4RED case, this phase plays out over three stages. Upon obtaining buy-in, training can be presented to the target audience. This phase is started by the development of training material for the target audience (F2/KDEV) in the first stage. It is mostly deemed as sufficient, and if any changes are made in the following stages, it are small and incremental and based on the feedback of previous stages. From Stage 2 onwards, a specific policy is developed to motivate the target audience to participate in the training program (F4/GOS). In each of the stages, training (F3/KDIF) is then

provided (mostly in the form of workshops) to two groups among the target audience: First, the general members of the target audience, that consists of the leadership personnel and teachers, and second, additional assistants to help the target audience. The leadership personnel receive work to do in their own time (F3/KDIF) and thereafter training for the teachers starts (F3/KDIF). In parallel, the second group receives training (F3/KDIF) that enables them to assist the general members of the target audience, and they become human resources (F6/RM). During one of the stages, the target audience develops their own content spontaneously (F2/KDEV). A need is then created for a way for the target audience to share their created content, which result in the formation of internal committees from the target audience to assist (F6/RM).

In the SVS case, this phase takes place over two stages. It is started as a field expert is recruited (F6/RM) to assist the project team and together they develop training material to be used for training activities (F2/KDEV). Training is presented by the field expert (F3/KDIF) and mid-level to lower-level management members of the target audience take part. The design of the training program is such that the members attending would be able to train other target audience members under their care. Therefore, once the training is completed, the attending target audience members become human resources within the project (F6/RM). This means that the solution can be implemented, and it becomes in use (F2/KDEV).

Conclusion

When comparing the three cases, a common pattern exists between them that forms the dynamic at the basis of this CLD. This dynamic includes the development of training material that is used to educate and provide training to the target audience. Once completed, training activities take place, which in turn results in members of the target audience becoming human resources in the project, enabled to educate other target audience members or assist the project team where necessary.

In addition to the dynamic forming the basis for this CLD, there are other dynamics also present, that usually occur as a result of the dynamic explained above. These dynamics are not necessarily present in all three cases and are mostly dependent on the design of the projects in the different cases.

The start of this CLD is derived from the SVS case. The necessary resources are obtained and aligned (F6/RM) to enable the development of the training material to be used in the training activities throughout. Once done, training material is developed (F2/KDEV), as shown in the ICT4RED and SVS cases. Once done, training activities are now able to take place, however, as shown by the Mafarafara and SVS cases, it may at first be necessary to raise advocacy among the target audience

to motivate them to partake in the training. Therefore, initial advocacy activities from the buy-in phases are revisited to maximise participation in the training activities and subsequently participation by the target audience for the remainder of the project (F4/GOS and F7/COL). Once done, training activities ensue (F3/KDIF) in various forms. The ICT4RED case shows how these activities can result in the development of additional material by the target audience themselves (F2/DEV) that can be used by other members of the target audience (F3/KDIF). Once training activities reach its completion, all three cases show how some members of the target audience become human resources within the project, by being able to educate other target audience members and assist the project team in various ways (F6/RM). The dynamics of the training and first usage phases within the cases are illustrated by the CLD in Figure 8-6.

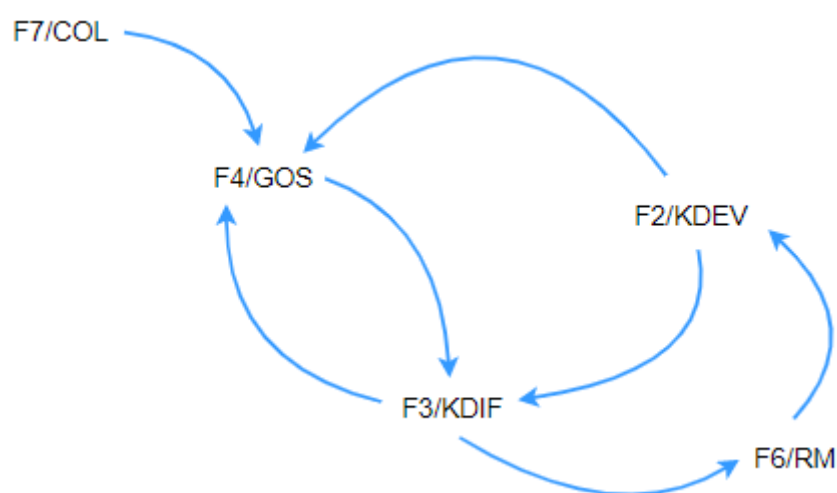


Figure 8-6 Training and First Usage CLD

8.5. Routine Usage, Feedback and Adjustment

In the Mafarafara case, this phase plays out a couple of months after the training activities were finished and the project was implemented among the target audience. The target audience are gathered where discussions are held and they share feedback regarding the project with the project team (F2/KDEV). The feedback is very positive, resulting in raising advocacy among the target audience regarding the positive impact that the project has had so far (F4/GOS and F7/COL). During the discussions, the project team continues to highlight important concepts such as ownership and empowerment (F4/GOS). The technology forming part of the project is upgraded (F6/RM) and further developed (F2/KDEV). In addition, more training activities take place (F3/DIF).

In the second phase, the project team focuses on activities that continue to build trustworthy relationships between them and the target audience (F7/COL). Further feedback is gathered and the target audience hails the positive impact of the project. In addition, other members of the target

audience who did not participate in the project also start to recognise the positive impact of the project and they express their appreciation (F7/COL). The usage of the technology becomes embedded in the daily routine of the target audience (F3/KDIF) and it develops further as new functionalities are added (F2/KDEV).

In the ICT4RED case, this phase develops across three different stages. It is started as resources in the form of technology and supporting infrastructure are distributed and installed (F6/RM). The target audience routinely makes use of the technology and they become accustomed to using it (F2/KDEV). Some members of the target audience develop their own content and they share it with others (F3/KDIF). After the target audience has been using the technology for a lengthy period, feedback is gathered from them by the members of the project team (F2/KDEV). Based on the feedback, new resources are acquired or upgraded to better suit the needs of the target audience (F6/RM). Further feedback shows how the project has positively impacted the behaviour of the target audience and that trustworthy relationships have formed among the target audience (F7/COL).

In the SVS case, some important activities were neglected in order to focus on the mass rollout of the project. Unfortunately, the result of this is that many members of the target audience require renewed training (F3/KDIF) and it is also necessary to re-communicate to them what their roles are and how it fits in within the project (F4/GOS). The decision is also made that the system is somewhat complex and it is adjusted to make it easier to use (F2/KDEV). Additional human resources are acquired when a specific company is sourced and tasked to provide consultation to improve process within the project. Additional project champions are also raised up from among the target audience to assist management groups from the target audience (F6/RM). To further improve the system, the government department involved in the project introduces mandates that the members of the target audience must adhere to (F5/MF). This department also develops documents, outlining the SOP, after it was found that this was initially lacking (F2/KDEV). These documents also outline the expectations from the target audience (F4/GOS). It comes to light that there is a lack of communication between the different target audience members. This issue is addressed and communication channels are developed (F3/KDIF).

More feedback from the target audience is gathered and they suggest certain changes that will assist them as they partake in the project (F2/KDEV). In response, the project team makes the necessary adjustments (F2/KDEV). Further feedback reveals that the target audience is very positive about the impact that the project has had on their daily routine (F7/COL). In addition, the government adds the project to a specific list that ensures that the project is used and its processes adhered to in each facility

of the target audience nationwide (F5/MF). As part of the adding the project to the list, it also refines the targets of the solution and sets it out in achievable steps (F4/GOS). This builds advocacy around the effect of the project and members of the target audience start to work together as trustworthy relationships are formed (F7/COL). Researchers also start to use the project in their studies and through this, additional feedback is gathered (F2/KDEV). From the feedback it is seen that there are still some problems through the eyes of the target audience, but in general the feedback is very positive (F7/COL). The researchers communicate their findings to the public (F4/GOS) that develops further advocacy regarding the positive effect of the solution (F7/GOS).

Conclusion

When comparing the phases in each of the three cases, there is not one particular repetition of fulfilment of functions that result in a general dynamic across the three cases, as has previously been the case in some of the CLDs previously discussed. However, there is a shared focus on obtaining feedback from the target audience and adjusting the system according to their needs, or to improve the functioning of the technology or project. This plays out in different ways across the three cases, often dependent on the technology or project. For all three cases, this is the first time that the project becomes fully functional among the target audience, and therefore one would expect that there should be adjustments to the project as valuable feedback is obtained for the first time. As the project becomes embedded among the target audience and it becomes part of their daily routine, one would expect that the adaptations of the project become less radical and more incremental as most of the big problems would have been sorted out. Changes are still expected as the project is consistently improved. Even though there is not a general dynamic present across all three cases, the synthesis of the three phases in the cases does offer valuable insight into adjustments that can be expected.

The start of the CLD is derived from the ICT4RED case as technological infrastructure is installed (F6/RM) to enable the target audience to routinely use the technology of the project. In turn, this results in learning-by-using (F2/KDEV) as the target audience starts to use the technology consistently and members of the target audience start to create their own content that gets shared with other target audience members (F3/KDIF). After the project has been implemented for some time so that insight from the target audience can be seen as valuable, the project team gathers feedback from the target audience (F2/KDEV). This takes place in all three cases. Insight from the SVS case shows that the adoption of the project is poor and that many members of the target audience require renewed training (F3/KDIF) and the project must also be explained to these members again (F4/GOS). This results in the first adaptation of the project and its systems as it is recognised that the systems are too complex (F2/KDEV). Based upon the initial feedback from the SVS case, the governmental

authorities develop a mandate that the members of the target audience must adhere to that keeps members of the target audience accountable to partake in the project (F5/MF). The target audience also expresses their concern about a lack of communication channels across the project and as a result effective communication channels are implemented (F3/KDIF). Next, as is shown by the ICT4RED and SVS cases, additional resources are gathered (F6/RM): Improved technology is obtained to better suit the needs of the target audience, and additional human resources are raised up to offer insight to improve the project and further assist the target audience with their needs. The insight to improve the project results in the second adaption of the implementation model of the project (F2/KDIF). Once most of the initial adaptations to the project are done, feedback is once again gathered from the target audience. This takes place in both the Mafarafara and ICT4RED cases, and the target audience expresses their appreciation for the project and highlight the positive impact it has had up to this point (F7/COL). In the ICT4RED case, the target audience particularly expresses their appreciation regarding the formation of trustworthy relationships between target audience members of different management levels, and states that the project has caused this (F7/COL). Next, in addition to the mandate developed by the governmental authorities, the project is added to a prestigious list by the authorities in the SVS case, ensuring that the project is used and adhered to across all target audience members (F5/MF). It is worth noting that this is done after the project has become functional among the target audience for a while already, and thus having proved its ability and positive effect, receives attention on a governmental level. This helps to communicate the goals of the project once more, as it is necessary to refine the targets of the project in achievable steps (F4/GOS). It also helps to build further advocacy around the project (F7/COL). Lastly, the SVS case shows how researchers begin to use the project in their studies (F2/KDEV). They communicate the outcomes to the public (F4/GOS) and this also builds further advocacy around the positive effect of the solution. The core dynamics of the routine usage, feedback and adjustment phases across the three cases is illustrated by the CLD in Figure 8-7.

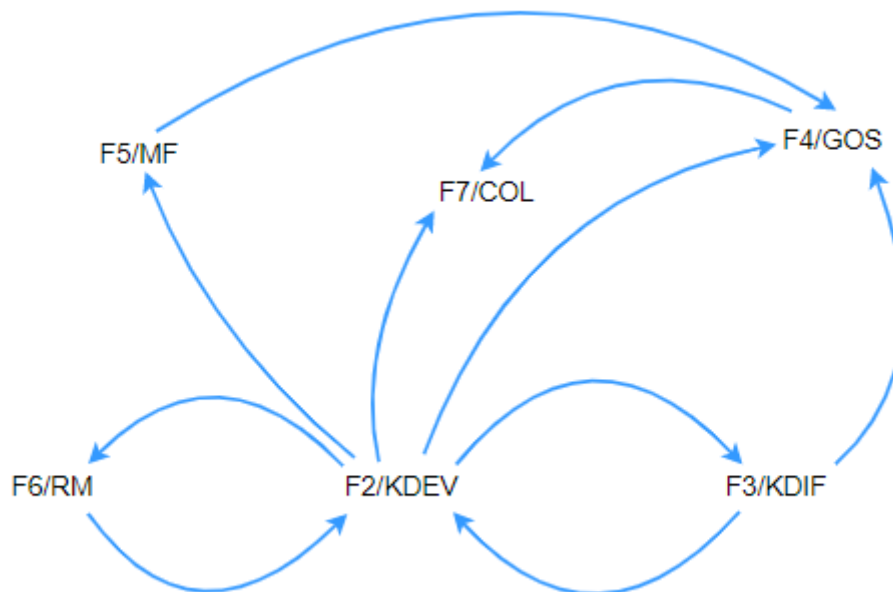


Figure 8-7 Routine Usage, Feedback and Adjustment CLD

8.6. Project Disengagement and Handover

As mentioned previously in Section 8.1, the ICT4RED case is the only case that has developed up to the stage where the project is disengaged from the project team's perspective, and where a handover takes place. This makes this CLD unique in the sense that repetition does not take place from which conclusions can be drawn. As a result, the outcomes of the phase in the ICT4REC case solely informs this CLD.

In this case, the phase is started as the project team creates a platform where they share the outcomes of the project with the public (F3/KDIF and F4/GOS). The communicated outcomes build legitimacy regarding the positive outcome of the project among the general public (F7/COL), which results in governmental authorities approaching the project team to use their methods to implement similar projects within similar contexts as those of the target audience (F5/MF). Furthermore, as a result of the advocacy built around the project, researchers collaborate with the project team (F3/KDIF) and they start to use the project in their studies (F2/KDEV). This further strengthens legitimacy around the project (F7/COL).

Once advocacy has been raised about the project, and the need and positive impact thereof has been made clear, stakeholders are willing to take over the project. The project team develops a document to guide the stakeholders that will take over the project in the further implementation thereof (F2/KDEV). Once this is done, the project is handed over, and the stakeholders begin to take

responsibility of the project (F5/MF). The core dynamics of the project disengagement and handover phase is illustrated by the CLD in Figure 8-8.

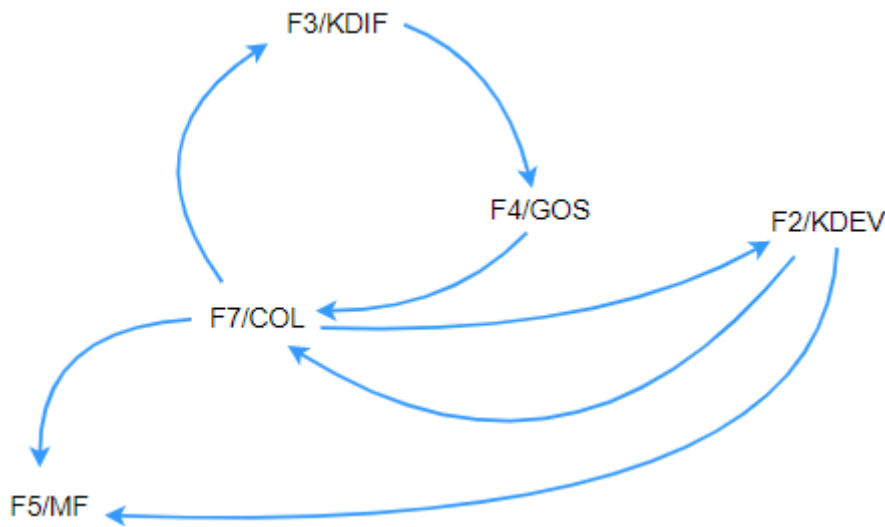


Figure 8-8 Project Disengagement and Handover Motor

8.7. Conclusion of Synthesis

The start of the I4IDS is informed by the pre-engagement project preparation CLD, as a market is formed by a problem that requires a solution, and subsequently a project is started to address this issue (F5/MF). The start of the project is characterised by entrepreneurial activities (F1/EA) to fund the solution project and by knowledge diffusion activities as collaboration between system actors occurs and partnerships are formed (F3/KDIF). This enables the actors responsible for the implementation of the project to focus on knowledge development activities (F2/KDEV) by doing research and developing an implementation model for the project. The model defines the roles of the different actors that become part of the project as human resources, thus stimulating resource mobilisation (F6/RM). In turn, these actors focus on additional knowledge development activities as further research and development is done (F2/KDEV) to refine and finish the implementation model for the project.

Depending on the I4IDS that the project is developed in, it may be necessary to engage with the target audience next to obtain their commitment: The Mafarafara and ICT4RED cases both form part of research projects and it is necessary to find out if the target audience identified earlier in the CLD by the research activities is willing to partake in the project. However, in the case of the ICT4RED and SVS cases, the participation of the target audience is secured by the government, who forms part of the actors responsible for the project. The engagement dynamics are included in the CLD: Once the implementation model has been finished, there is a focus on knowledge diffusion and guidance of search activities (F3/KDIF and F4/GOS) as contact is made with the target audience and the

objectives and vision of the project are explained. This creates legitimacy regarding the project from among the target audience (F7/COL) and a willingness to participate in the project in principle (F7/COL). The red arrows in Figure 8-9 show the causal chains and causal loops between the functions from the *pre-engagement project preparation CLD* and they contribute toward the final CLD of the synthesised cases.

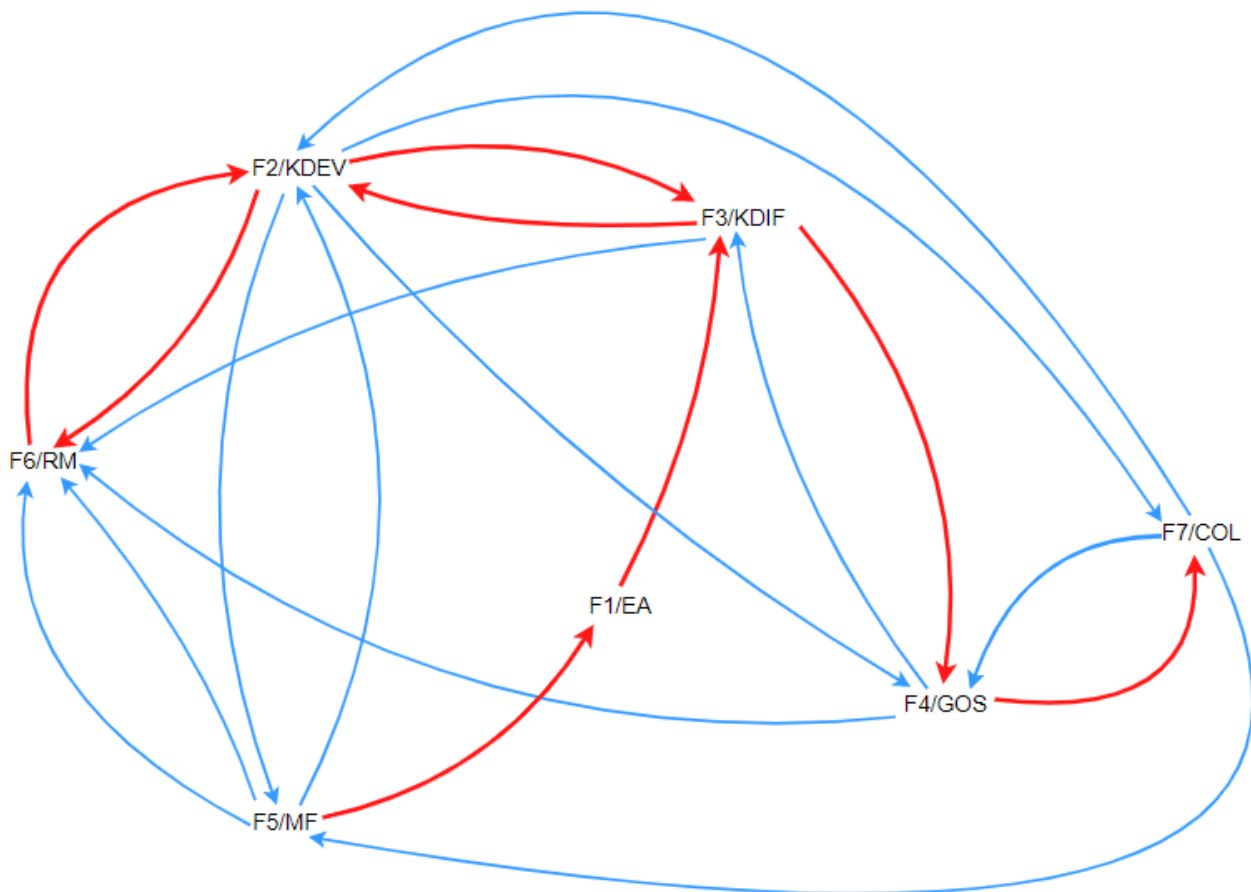


Figure 8-9 Contribution from Pre-engagement Project Preparation CLD towards final CLD

Even though there is a focus on creation of legitimacy at the end of the first CLD, it is only an agreement in principle by the target audience to obtain their participation. It is still very important to obtain buy-in from all target audience members – not only to obtain their participation, but also to develop a sincere willingness to partake in the project.

Therefore, at the start of obtaining buy-in from the target audience CLD, there is a big focus on creation of legitimacy activities through the building and formation of trustworthy relationships between the project team and target audience (F7/COL). Once the relationships have been formed, the focus shifts towards guidance of search activities (F4/GOS) as the desired outcomes, vision and objectives of the project are shared with the target audience. This results in raised advocacy

surrounding the project among the target audience, obtaining their buy-in (F7/COL). Importantly, this dynamic is often repeated to obtain-buy-in from various groups within the target audience.

The obtained buy-in from the target audience in some instances results in efforts from the target audience to promote participation the project, as is particularly shown in the ICT4RED case: Governmental authorities forming part of the target audience develop policies to get more people involved as human resources, showing how market formation activities (F5/MF) can lead to resource mobilisation (F6/RM). Additionally, partnerships between the target audience and the project team are formed (F4/GOS), resulting in the same effect to mobilise human resources (F6/RM). Figure 8-10 shows how the functions from the *obtain buy-in from target audience CLD* contributes toward the final CLD of the synthesised cases.

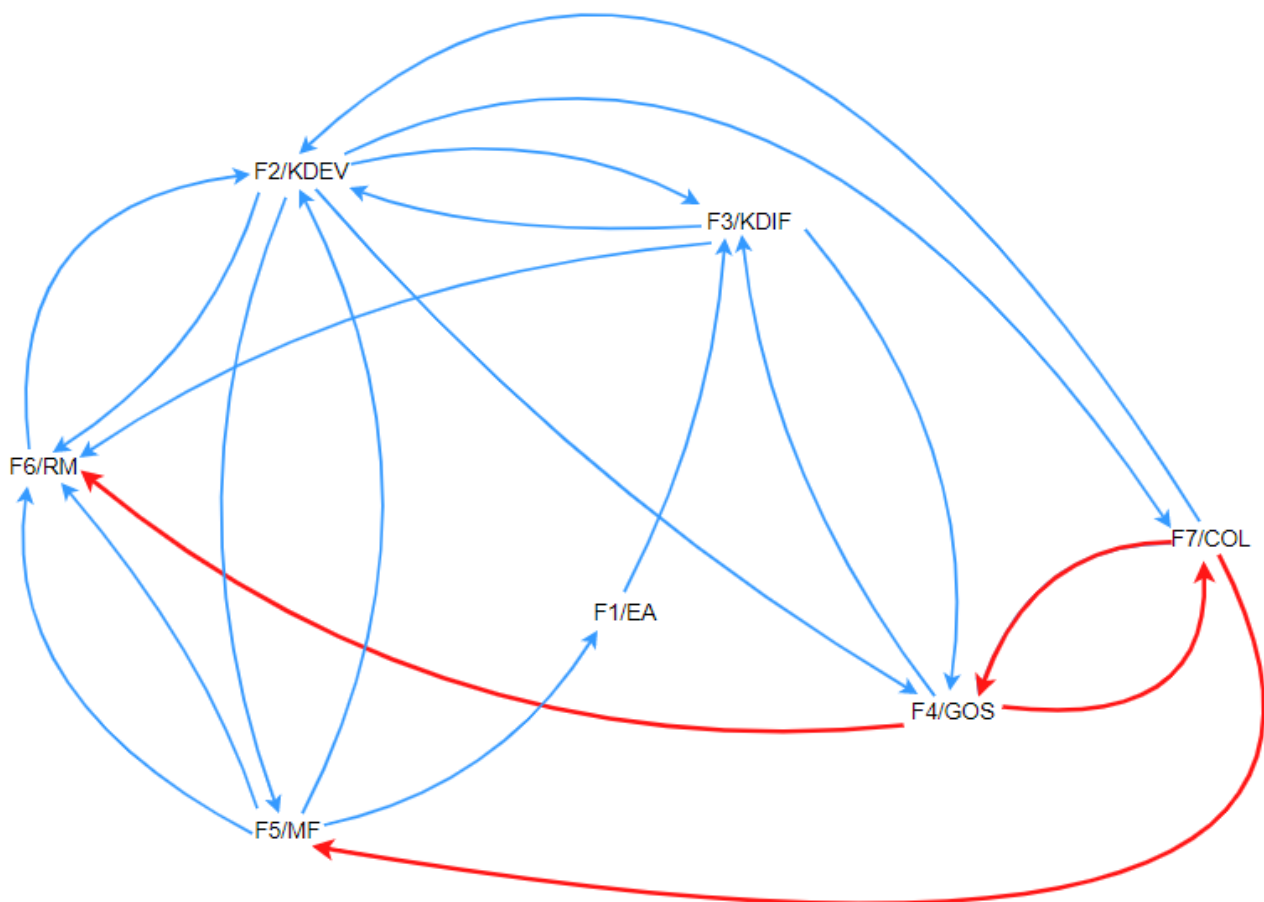


Figure 8-10 Contribution from Obtain Buy-in from Target Audience CLD towards final CLD

At the start of the training and first usage CLD, the focus is on knowledge development activities (F2/KDEV) to develop training material to be used to present training to the target audience. Once done, guidance of search and creation of legitimacy activities (F4/GOS and F7/COL) are revisited from the previous CLD to motivate target audience members to take part in training. These activities

are followed by knowledge diffusion activities as the focus shifts towards providing various forms of training to the target audience (F3/KDIF). Depending on the type of project or I4IDS, at the conclusion of training, target audience members are empowered and able to apply what was learned to develop new information to be used by other actors in the system, thus contributing to knowledge development activities (F2/KDEV) that are followed by knowledge diffusion activities as the created information is distributed to other actors within the system (F3/KDIF). Lastly, training activities enable certain members of the target audience to become human resources within the project as assistants, thus contributing to resource mobilisation (F6/RM). Figure 8-11 shows how the functions from the *training and first usage CLD* contributes toward the final CLD of the synthesised cases.

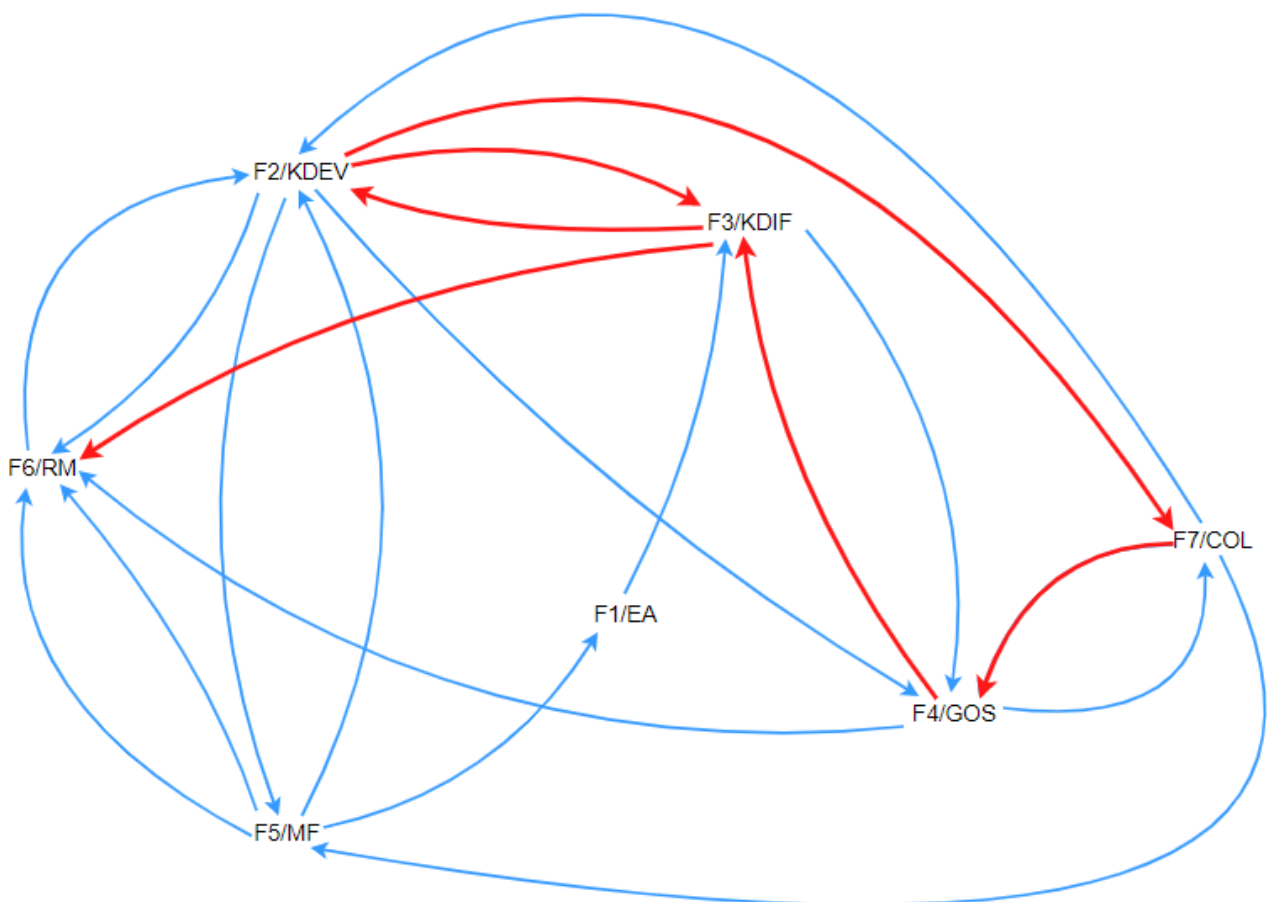


Figure 8-11 Contribution from Training and First Usage CLD towards final CLD

The routine usage, feedback and adjustment CLD begins with the project being implemented among the target audience for a substantial time. At the start of the CLD, there is a big emphasis on knowledge development and diffusion activities: Since the project becomes embedded in the lives of the target audience, learning-by-using takes place (F2/KDEV) and members of the target audience who created content of their own, share it with other target audience members (F3/KDIF).

The focus then shifts specifically to knowledge development activities (F2/KDEV) as feedback from the target audience is gathered. During this time when feedback is gathered, the pattern of obtaining feedback and adjusting the system accordingly is repeated multiple times. There is therefore a continued focus on knowledge development activities, in parallel with a shifting focus on other activities as the project is adjusted according to the feedback. Some of these resulting activities may be the following: First, because the project performs poorly as a result of a weak understanding of the project among the target audience (because of a lack of good communication channels), knowledge diffusion and guidance of search activities become the focus (F3/KDIF and F4/GOS). Second, the project or technology gets adjusted to suit the needs of the target audience, again focussing on knowledge development activities (F2/KDEV). Third, government form policies, advocating for the usage of the project among the target audience, highlighting the shift towards market formation activity (F5/MF).

As this CLD develops and important adjustments have been made to improve the project, renewed feedback is gathered (F2/KDEV) and advocacy regarding the positive effect of the project is raised among the target audience, therefore resulting in the creation of legitimacy (F7/COL). This results in more knowledge development activities, as researchers use the project in their studies (F2/KDEV). Lastly, guidance of search and creation of legitimacy activities occur (F4/GOS and F7/COL), when the researchers communicate their findings to the public, further improving legitimacy. Figure 8-12 shows how the functions from the *routine usage, feedback and adjustment CLD* contributes toward the final CLD of the synthesised cases.

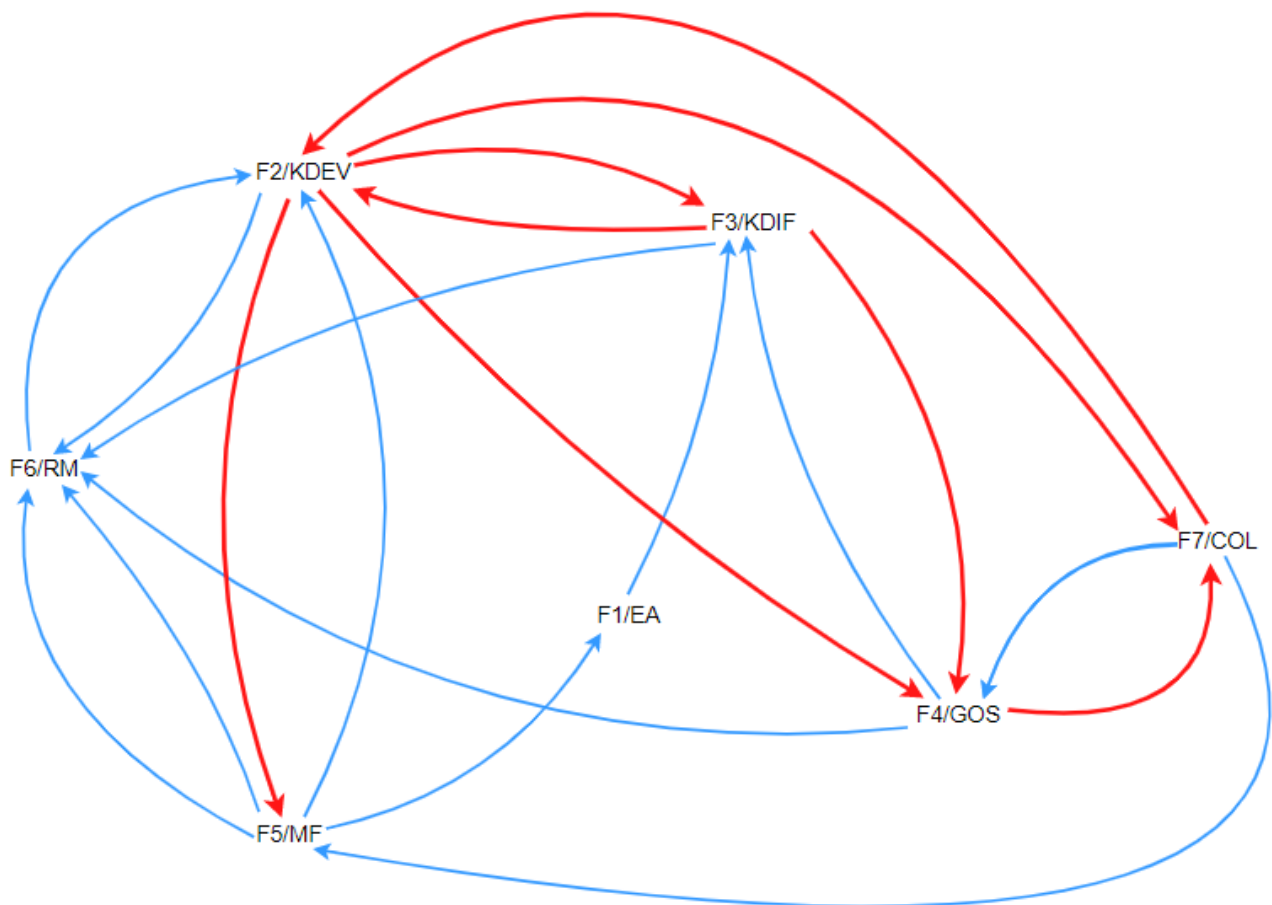


Figure 8-12 Contribution from Routine Usage, Feedback and Adjustment CLD towards final CLD

The project disengagement and handover CLD starts as the project team's activities are directed towards knowledge development and guidance of search, by creating a platform to communicate the outcomes of the project to the public (F3/KDIF and F4/GOS). This creates legitimacy around the project (F7/COL), that arguably results in a focus on market formation as governmental authorities enquire about using the project within other areas (F5/MF). Additionally, more researchers use the project in their studies, strengthening the legitimacy already surrounding the project. Lastly, focus shifts to knowledge development activities (F2/KDEV) as a final implementation model is documented to assist actors who will take ownership of the project in the future, and ultimately, the project is handed over to the new actors. Figure 8-13 shows how the functions from the *project disengagement and handover CLD* contributes toward the final CLD of the synthesised cases.

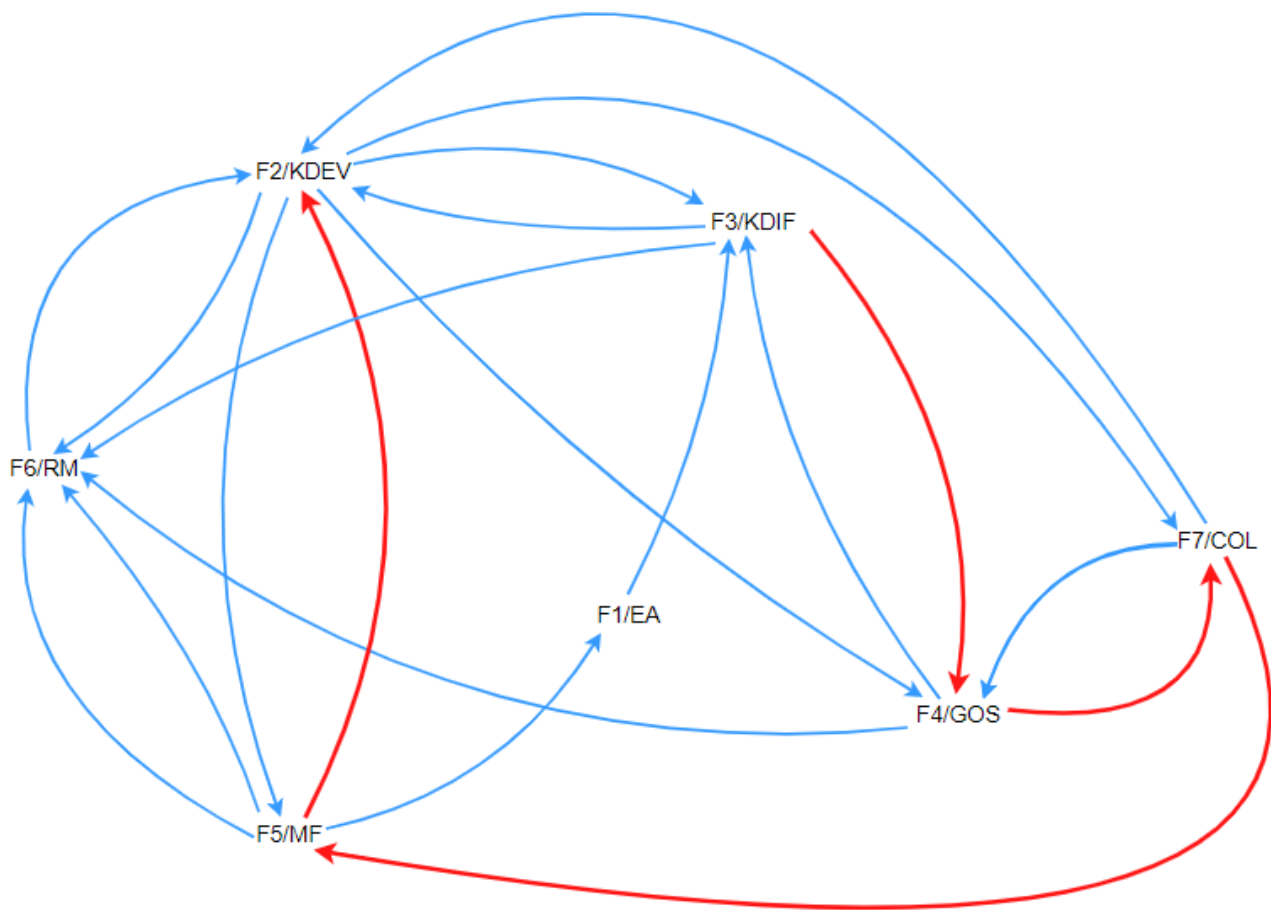


Figure 8-13 Contribution from Project Disengagement and Handover CLD towards final CLD

8.8. Chapter Summary

As per the EHA method explained in Section 2.1 and the analytical approach discussed in Chapter 4, the final step of this method is to synthesise the outcome of the different cases to develop general insight into the CLDs that are present across the cases to construct a final CLD. This chapter deals with this, and it results in the formation of five CLDs across the three cases and one final CLD that combines the insight from all five CLDs together. The first of the five CLDs is the *Pre-engagement Project Preparation* CLD, discussed in Section 8.2. The second is the *Obtain Buy-in from Target Audience* CLD, discussed in Section 8.3. The third is the *Training and First Usage* CLD, discussed in Section 8.4. The fourth is the *Routine Usage, Feedback and Adjustment* CLD, discussed in Section 8.5. The fifth, and last, is the *Project Disengagement and Handover* CLD, discussed in Section 8.6. The final CLD is discussed in Section 8.7.

Chapter 9

Conclusions and Recommendations

Within this chapter, the conclusions of the research project are made in addition to recommendations for further study. This process is started in Section 9.1 by providing the research summary of the project according to the four parts of the research design of this project. This is followed by concluding this project in Section 9.2 by referring to the obtainment of the research objectives that were initially introduced at the start of this document in Section 1.3. In Section 9.3 the shortcomings and limitations of the project are discussed, and in Section 9.4 recommendations and possibilities for future work are given.

9.1. Research Summary

As mentioned in Section 1.3, the primary aim of this research project was to uncover the core dynamics present in I4IDS and construct a narrative to show the development of the dynamics as the system evolves over time. In Section 2.3, four primary parts were identified to achieve this aim:

1. Problem statement formulation and literature review
2. Formulation of analytical approach to analyse I4IDS dynamics
3. Case study analysis
4. Synthesis

Table 9-1 shows how the different chapters in this document contributed to the research method as described in Chapter 2.

Table 9-1 Research Summary

Part	Execution	Chapters
1. Problem statement formulation and literature review	<ul style="list-style-type: none"> • Provided background of innovation and its enablement for economic growth and unfortunate consequence of inequality. • Introduced I4IDS perspective aiming to alleviate inequality. • Mentioned that there is a weak understanding of I4IDS and the dynamics present, often resulting in failed I4ID projects. • Introduced EHA as a research method to uncover dynamics to improve understanding. • Provided primary research aim, objectives, scope and limitations of the project. 	Chapter 1, Chapter 3

	<ul style="list-style-type: none"> Conducted a literature review in Chapter 3 to identify indicators of system functions to enable mapping of functions to events. 	
2. Formulation of analytical approach to analyse I4IDS dynamics	<ul style="list-style-type: none"> Used EHA research method to formulate the five-step analytical framework to be used in analysing the three case studies in Chapter 5, Chapter 6 and Chapter 7. 	Chapter 4
3. Case study analysis	<ul style="list-style-type: none"> Applied the first four steps of the analytical framework to all three case studies: Data was collected to identify events and a database was constructed. The events were related to the system functions they fulfil. Phases within the cases were identified and interaction and trend patterns were identified. A narrative in the form of a CLD was developed for each case. 	Chapter 5, Chapter 6, Chapter 7
4. Synthesis	<ul style="list-style-type: none"> Applied the last step of the analytical framework to synthesise the findings of each case: Identified similar phases across the cases according to similar objectives, outcomes and key activities, and grouped them together. Compared the findings of each phase to develop a common narrative in the form of a CLD, that explained the dynamics within the communal phase. Synthesised the findings of each communal phase and constructed a final narrative in the form of a CLD, explaining the core dynamics present in I4IDS. 	Chapter 8

9.2. Conclusions Pertaining to Research Objectives

As mentioned in Section 1.3, the primary aim of this research project was to identify the core dynamics present in I4IDS and construct a narrative to show the development of the dynamics as the system evolves over time, by mapping the dynamics between the system functions.

To achieve the primary aim of this research project, four research objectives were identified in Section 1.3. These were the following:

1. Identify indicators of system functions to relate case events to the functions they fulfil.
2. Formulate an analytical approach using EHA with the IS and I4IDS perspectives that can be used to analyse I4ID project case studies.

3. Construct a CLD for each case consisting of the core dynamics, demonstrating how the various functions work together during different phases throughout each case to achieve the desired outcomes.
4. Synthesise the results of each case to develop a common narrative between the cases in the form of a CLD showing how the various functions work together during different phases to achieve the desired outcomes.

9.2.1. Conclusion Relevant to Objective 1

Within Chapter 3, a literature review was done to gain an understanding of the latest systems view of innovation known as the IS perspective. The components and functions that the perspective consists of are also covered. Next, the I4IDS perspective was studied and the components and functions of the conventional IS perspective are compared to how it was represented in the I4IDS perspective. Lastly, because of the added complexity of the I4IDS perspective, the additional foci and activities found across the seven system functions are explored. In using the literature covered as mentioned above, the descriptions of the functions, additional focal areas coming from I4IDS and example activities are used as indicators of system functions that enabled the mapping of events to the functions.

9.2.2. Conclusion Relevant to Objective 2

By using the EHA research method, a five-step analytical approach was formulated in Chapter 4 to analyse I4ID project case studies. The first and second step consisted of gathering data to identify events within a case and then sorting the events chronologically. In the third step, two tables were constructed that contained the indicators of the system functions from the IS and I4IDS perspectives, as identified in Chapter 3. In the fourth step, the approach to identify the different phases, interaction patterns and trend patterns were described, often drawing on the work of Suurs (2009). Within the fifth and final step, the approach to synthesise the findings of different case studies using the objectives, outcomes and key activities, was implemented.

9.2.3. Conclusion Relevant to Objective 3

The core dynamics present in each case were identified by applying the developed analytical approach formulated in Chapter 4 (See Research Objective 2) to three cases where an I4ID intervention was implemented with success within marginalised communities. This was documented in Chapter 5 for the Mafarafara case, Chapter 6 for the ICT4RED case and Chapter 7 for the SVS case. In each case, event data were collected and a database with the events was constructed. The events were successfully related to the functions they fulfilled. Based on the objectives, outcomes and activities, each case was divided into different phases. The fulfilment of the functions within each phase was

illustrated with an events map that was used to identify causal chains. The causal chains were used to identify feedback loops within the phases that were ultimately used to construct a CLD for each case, illustrating the core dynamics.

9.2.4. Conclusion Relevant to Objective 4

Within Chapter 8, the various phases in each case study (identified in Chapter 5-Chapter 7) were grouped together based on similar objectives, outcomes and key activities. After grouping the similar phases, four communal phases across the three cases were identified and a fifth project handover phase was added that only occurred in one of the cases, but it was also the only case that developed to the point of handover. The findings of the similar case study phases were synthesised to develop a narrative in the form of a CLD for each communal phase. The five CLDs of the communal phases were used to construct a narrative in the form of a final CLD that showed how the various functions work together during different phases of the synthesised I4IDS to achieve the desired outcomes.

9.3. Shortcomings and Limitations

The EHA method is an adequate method to analyse case studies to identify specific dynamics between the system functions within the cases and then enabling the mapping thereof in the form of events map, causal chains, feedback loops and CLDs. However, the system components are not specifically tracked using this method, as already highlighted in Section 2.1.5 citing Suurs (2009). It is argued that functions can be traced back to the components if required, but within the dynamics the components are not specifically shown. In this research project that specifically aim to enhance the understanding of the core dynamics within I4ID projects and systems, it is not necessary, however.

Even though the outcome of the case study analysis is strengthened by repetition during the synthesis process, there are notable differences within each case study. The nature of the EHA method is that typically only three to five cases are analysed (Suurs, 2009). As the differences between the cases show, there are unique insights brought forth by each case that are case-specific and perhaps crucial to the success of the specific I4ID project that can only be identified by analysing the specific case. This research project therefore by no means claim to have identified all or even most of the core dynamics within I4IDS, but certainly contributes to an improved understanding of some the core dynamics. The *Obtain buy-in from the target audience* communal phase serves as an example. This dynamic has been identified in all three cases, and it would be unlikely that a I4ID project would be successful without this core dynamic.

9.4. Recommendations for Future Work

As pointed out in Section 9.3, it is very likely that some core dynamics within I4IDS were not identified in this research project. The analysed case studies were of a combined education/ICT and agricultural context (Mafarafara case study), educational context (ICT4RED case study) and healthcare context (SVS case study). There are many other possible contexts that can be analysed, most notably in agriculture, which according to Heeks, Foster and Nugroho (2014) is the sector in which the I4IDS models have been applied, although it is still weakly understood according to (Odame *et al.*, 2020). (Even though the Mafarafara case study partially focussed on agriculture, the primary focus of the case events was the on the diffusion of the ICT platform that educated the target audience regarding some agricultural aspects.)

Additionally, the understanding of the core dynamics within I4IDS can be used as the basis of the development of SD models that can be used to model such systems in the future. Other SD techniques and methods can be implemented besides feedback loops and CLDs that will further contribute to an improved understanding of I4ID projects.

9.5. Chapter Summary

The research summary of this project is given in Section 9.1 according to the four parts that were initially first set out in Section 2.3. This is followed by reflecting on the achievement of the research objectives of this research project (See Section 1.3) in Section 9.2. The next section (Section 9.3) discusses the identified shortcomings and limitations of the research project. Lastly, Section 9.4 offers recommendations and possibilities for future work.

References

Abell, P. (1987) *The Theory and Method of Comparative Narratives*. Edited by Clarendon Press. Oxford.

Ahmadian, A. (2008) *System dynamics and technological innovation system*. CHALMERS UNIVERSITY OF TECHNOLOGY. doi:10.1503/cmaj.1031912.

Altenburg, T. (2008) “Building inclusive innovation systems in developing countries – why it is necessary to rethink the policy agenda,” in *IV Globelics Conference*. Mexico City.

Apleni, A. and Smuts, H. (2020) “An e-Government Implementation Framework: A Developing Country Case Study,” in. doi:10.1007/978-3-030-45002-1_2.

Barjis, J., Kolfshoten, G. and Maritz, J. (2013) “A sustainable and affordable support system for rural healthcare delivery,” *Decision Support Systems*, 56. doi:10.1016/j.dss.2013.06.005.

Bazán, M., Sagasti, F. and Cárdenas, R. (2014) “National system of innovation for inclusive development: achievements and challenges in Peru,” in *National Innovation Systems, Social Inclusion and Development*. Edward Elgar Publishing, pp. 169–198. doi:10.4337/9781782548683.00011.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. and Rickne, A. (2008) “Analyzing the functional dynamics of technological innovation systems: A scheme of analysis,” *Research Policy*, 37(3), pp. 407–429. doi:10.1016/j.respol.2007.12.003.

Biggs, S.D. (2001) *Review of the Crop Post-Harvest Research Programme: Partnerships and Innovation Systems*.

Bildik, Y. (2014) “Modelling Innovation Diffusion: A comparative system dynamics study between California, US and Denmark,” (2010), pp. 1–18.

Botha, L., Grobbelaar, S.S. and Bam, W.G. (2019) “Developing an evaluation framework for university-driven technology-based, innovation for inclusive development (UTI4ID) projects,” *Research Evaluation*, 28(4). doi:10.1093/reseval/rvz021.

Bryden, J., Gezelius, S.S., Refsgaard, K. and Sutz, J. (2017) “Inclusive innovation in the bioeconomy: Concepts and directions for research,” *Innovation and Development*, 7(1), pp. 1–16. doi:10.1080/2157930X.2017.1281209.

Carlsson, B., Jacobsson, S., Holmen, M. and Rickne, A. (2002) “Innovation systems: Analytical and methodological issues,” *Research Policy*, 31(2), pp. 233–245. doi:10.1016/S0048-7333(01)00138-X.

Carlsson, B. and Stankiewicz, R. (1991) “On the nature, function, and composition of technological systems.pdf,” *Journal of Evolutionary Economics*, 1, pp. 93–118.

Chataway, J., Hanlin, R. and Kaplinsky, R. (2013) *INCLUSIVE INNOVATION: AN ARCHITECTURE FOR POLICY DEVELOPMENT*.

Chataway, J., Hanlin, R. and Kaplinsky, R. (2014) “Inclusive Innovation: An Architectue for Policy Development,” *Innovation and Development*, 4 (March), pp. 33–54.

Chianca, T. (2008) “The OECD/DAC Criteria for International Development Evaluations: An Assessment and Ideas for Improvement.” Available at: <http://evaluation.wmich.edu/jmde/>.

Chowles, T. (2016) *NDoH Deploys SVS mHealth App to Prevent Stock-outs*, *eHealth News*. Available at: <http://ehealthnews.co.za/ndoh-svs-mhealth-stock-outs/> (Accessed: September 22, 2020).

Chung, S. (2002) “Building a national innovation system through regional innovation systems,” *Technovation*, 22(8), pp. 485–491. doi:10.1016/S0166-4972(01)00035-9.

Clifford, K.L. and Zaman, M.H. (2016) “Engineering, global health, and inclusive innovation: focus on partnership, system strengthening, and local impact for SDGs,” *Global Health Action*, 9(1). doi:10.3402/gha.v9.30175.

Cooke, P., Uranga, M.G. and Etxebarria, G. (1998) “Regional systems of innovation: an evolutionary perspective,” *Environment and Planning A*, 30(9), pp. 1563–1584. doi:10.1068/a301563.

Coyle, R.G. (1996) *System Dynamics Modelling: A Practical Approach*. New York: Chapman & Hall.

Cozzens, S. and Sutz, J. (2012) *Innovation in informal settings: a research agenda*, IDRC, Ottawa, Canada. doi:10.1080/2157930X.2013.876803.

Cozzens, S. and Sutz, J. (2014) “Innovation in informal settings: reflections and proposals for a research agenda,” *Innovation and Development*, 4(1). doi:10.1080/2157930X.2013.876803.

Cozzens, S.E. and Kaplinsky, R. (2009) “Innovation, poverty and inequality: Cause, coincidence, or co-evolution?,” *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting*, pp. 57–82. doi:10.4337/9781849803427.00009.

CSIR Meraka and Benita Williams Evaluation Consultants (2015) *ICT4RED FINAL EVALUATION SUMMARY REPORT*.

Daniels, C.U., Ustyuzhantseva, O. and Yao, W. (2017) “Innovation for inclusive development, public policy support and triple helix: perspectives from BRICS,” *African Journal of Science, Technology, Innovation and Development*, 9(5). doi:10.1080/20421338.2017.1327923.

Data Innovator (2017) *Evaluation of Stock Visibility Solution Implementation in Umzinyathi and Amajuba Districts*.

Dodson, L.L., Sterling, S.R. and Bennett, J.K. (2012) “Considering failure,” in *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development - ICTD '12*. New York, New York, USA: ACM Press. doi:10.1145/2160673.2160681.

Doloreux, D. (2002) “What we should know about regional systems of innovation,” *Technology in Society*, 24(3), pp. 243–263. doi:10.1016/S0160-791X(02)00007-6.

Edquist, C. (1997) “Systems of Innovation Approaches - Their Emergence and Characteristics,” *Systems of Innovation: Technologies, Institutions and Organizations*, (January 2000), pp. 1–35. doi:10.1016/S0024-6301(98)90244-8.

Edquist, C. and Hommen, L. (1999) “Systems of innovation: Theory and policy for the demand side,” *Technology in Society*, 21(1), pp. 63–79. doi:10.1016/S0160-791X(98)00037-2.

Edquist, C. and Johnson, B. (1997) “Institutions and organizations in systems of innovation,” *Systems of innovation: Technologies, institutions and organizations*, (January 1997), pp. 41–63. doi:10.1016/S0024-6301(98)90244-8.

Forrester, J.W. (1976) *Principles of Systems*. Cambridge: MIT Press.

Foster, C. and Heeks, R. (2013) “Conceptualising inclusive innovation: Modifying systems of innovation frameworks to understand diffusion of new technology to low-income consumers,” *European Journal of Development Research*, 25(3), pp. 333–355. doi:10.1057/ejdr.2013.7.

Foster, C. and Heeks, R. (2014) “Nurturing user–producer interaction: inclusive innovation flows in a low-income mobile phone market,” *Innovation and Development*, 4(2), pp. 221–237. doi:10.1080/2157930x.2014.921353.

Foster, C. and Heeks, R. (2015) “Policies to Support Inclusive Innovation,” *Centre for Development Informatics* [Preprint].

Freeman, C. (1987) *Technology and Economic Performance: Lessons from Japan*. London: Pinter.

Freeman, C. (1995) “The ‘National System of Innovation’ in historical perspective,” *Cambridge Journal of Economics*, 19(1), pp. 5–24. doi:10.1093/oxfordjournals.cje.a035309.

Fryatt, R. and Hunter, J. (2015) *The Ideal Clinic in South Africa: Planning for implementation*.

Galanakis, K. (2006) “Innovation process. Make sense using systems thinking,” *Technovation*, 26(11), pp. 1222–1232. doi:10.1016/j.technovation.2005.07.002.

George, G., McGahan, A.M. and Prabhu, J. (2012) “Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda,” *Journal of Management Studies*, 49(4). doi:10.1111/j.1467-6486.2012.01048.x.

Godin, B. (2006) “The Linear Model of Innovation,” *Science, Technology, & Human Values*, 31(6), pp. 639–667. doi:10.1177/0162243906291865.

Godin, B. (2007) “National Innovation System : The System Approach in Historical Perspective,” (36), pp. 1–37.

Govender, I. (2016) *2015 Stock Outs National Survey: Third Annual Report – South Africa*.

Grobbelaar, S. and van der Merwe, E. (2016) “Supporting Inclusive Innovation: Developing Improved Analytical Methods and STI Policy Instruments to Operationalise Inclusive Innovation,”

in *Portland International Conference on Management of Engineering and Technology (PICMET)*, pp. 90–102.

Grobbelaar, S.S. and Buys, A.J. (2006) *A System Dynamics Model of R & D in the South African System of Innovation*. University of Pretoria.

Grossman, G.M. and Helpman, E. (1994) *Endogenous Innovation in the Theory of Growth*, *Journal of Economic Perspectives*.

GSM Association (2018) *Mezzanine's Stock Visibility Solution*.

Guan, J. and Chen, K. (2012) "Modeling the relative efficiency of national innovation systems," *Research Policy*, 41(1), pp. 102–115. doi:10.1016/j.respol.2011.07.001.

Gush, K. *et al.* (2010) "Digital Doorways," in Steyn, J., Van Belle, J.P., and Mansilla, E.V. (eds) *ICT for Global Development and Sustainability: Practice and Applications*. New York: Hersey.

Hardoon, D. (2015) *WEALTH: HAVING IT ALL AND WANTING MORE*. Available at: www.oxfam.org.

Health Systems Trust (2019) *The CCMDD story*.

Heeks, R., Foster, C. and Nugroho, Y. (2014) "New models of inclusive innovation for development," *Innovation and Development*, 4(2), pp. 175–185. doi:10.1080/2157930X.2014.928982.

Heeks, R. and Ospina, A. v. (2019) "Conceptualising the link between information systems and resilience: A developing country field study," *Information Systems Journal*, 29(1). doi:10.1111/isj.12177.

Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S. and Smits, R.E.H.M. (2007) "Functions of innovation systems: A new approach for analysing technological change," *Technological Forecasting & Social Change*, 74, pp. 413–432. doi:10.1016/j.techfore.2006.03.002.

Hekkert, M.P., Negro, S.O., Heimeriks, G. and Harmsen, R. (2011) "Technological Innovation System Analysis: A manual for analysts."

Hekkert, M.P., Harmsen, R. and De Jong, A. (2007) “Explaining the rapid diffusion of Dutch cogeneration by innovation system functioning,” *Industrial and Corporate Change*, 13(5), pp. 815–849. doi:10.1016/j.enpol.2007.02.018.

Hekkert, M.P. and Negro, S.O. (2009) “Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims,” *Technological Forecasting and Social Change*, 76(4), pp. 584–594. doi:10.1016/j.techfore.2008.04.013.

Herselman, M. and Botha, A. (2014) *Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained environment: Cofimvaba school district, Eastern Cape, South Africa*. 1st edn. CSIR Meraka: Pretoria, South Africa.

Hussain, B.M. and Chen, D. (2018) “Information & Communication Technology (ICT) Can Change the Way of Women Entrepreneurs Run their Businesses: A Case Study in Bangladesh,” in *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE. doi:10.23919/PICMET.2018.8481852.

Iizuka, M. (2013) *Innovation systems framework: Still useful in the new global context?* doi:10.20955/r.85.67.

Ismail, T., Ansell, G. and Kleyn, N. (2012) *New markets, new mindsets: Creating wealth with South Africa's low-income communities through partnership and innovation*. Jacana Media.

Iwu, C., Ngcobo, N., Cooper, S. (2020) “Mobile reporting of vaccine stock-levels in primary health care facilities in the Eastern Cape Province of South Africa: perceptions and experiences of health care workers,” *Human Vaccines and Immunotherapeutics*, 16(8), pp. 1911–1917. doi:10.1080/21645515.2019.1700713.

Jacobsson, S. and Carlsson, B. (1997) *Diversity Creation and Technological Systems: A Technology Policy Perspective*. Edited by C. Edquist. Pinter.

Jacobsson, S. and Lauber, V. (2006) “The politics and policy of energy system transformation - Explaining the German diffusion of renewable energy technology,” *Energy Policy*, 34(3), pp. 256–276. doi:10.1016/j.enpol.2004.08.029.

Johnson, A. (2001) “Functions in innovation system approaches,” in *Electronic paper presented at the the Nelson and Winter Conference, Aalborg, Denmark, 12–15 June 2001*, pp. 1–19.

Johnson, B. (1992) *Institutional Learning*. Edited by B.Å. Lundvall. London: Printer.

Kaplinsky, R. (2011) “Schumacher meets Schumpeter: Appropriate technology below the radar,” *Research Policy*, 40(2), pp. 193–203.

Kim, S.W., Ro, G. and Florida, U.S. a (2009) “Dynamic Analysis of Technological Innovation Using System Dynamics,” in *POMS 20 th Annual Conference*, pp. 1–33.

Kraemer-Mbula, E. and Wamae, W. (2010) “Adapting the Innovation Systems Framework to Sub-Saharan Africa,” in *Innovation and the Development Agenda*. Paris: OECD Publishing.

Krauss, K. (2009) “Ethical research practice for community entry: using ICT4D in a deep rural context,” in *3rd International IDIA Development Informatics Conference*.

Kuhlmann, S. and Rip, A. (2015) “Evolving Concertation - New constellations of actors addressing Grand Challenges,” *Innovation policies for economic and social transitions: Developing strategies for knowledge, practices and organizations* [Preprint].

Lee, T.L. and Von Tunzelmann, N. (2005) “A dynamic analytic approach to national innovation systems: The IC industry in Taiwan,” *Research Policy*, 34(4), pp. 425–440. doi:10.1016/j.respol.2005.01.009.

Long, T.B., Blok, V. and Coninx, I. (2019) “The diffusion of climate-smart agricultural innovations: Systems level factors that inhibit sustainable entrepreneurial action,” *Journal of Cleaner Production*, 232. doi:10.1016/j.jclepro.2019.05.212.

Lundvall, B.Å. (1992) *National Systems of Innovation: Towards a Theory of innovation and Interactive Learning*. London: Pinter.

Maarsingh, B., Grobbelaar, S., Uriona-Maldonado, M. and Herselman, M. (2021) “Exploring functional dynamics of innovation for inclusive development: event history analysis of an ICT4D project,” *Innovation and Development* [Preprint]. doi:10.1080/2157930X.2021.1956712.

Mair, J., Martí, I. and Ventresca, M.J. (2012) “Building inclusive markets in rural Bangladesh: How intermediaries work institutional voids,” *Academy of Management Journal*, 55(4), pp. 819–850. doi:10.5465/amj.2010.0627.

Malerba, F. (2002) “Sectoral systems of innovation and production,” *Research Policy*, 31, pp. 247–264.

Mbuyisa, B. and Leonard, A. (2017) “The Role of ICT Use in SMEs Towards Poverty Reduction: A Systematic Literature Review,” *Journal of International Development*, 29(2). doi:10.1002/jid.3258.

Medecins Sans Frontiers, Rural Health Advocacy Project, Section 27 and Treatment Action Campaign (2013) *Emergency Intervention at Mthatha Depot: The hidden cost of inaction*, 6th South African AIDS Conference, Durban, 19 June.

Mezzanine (2020a) *Medical Stock Visibility App*. Available at: <https://mezzanineware.com/digital-productivity-technology/healthcare-technology-solutions/medical-stock-visibility-app/> (Accessed: September 23, 2020).

Mezzanine (2020b) *South African National Department of Health Using Stock Visibility Solution To Provide Real-Time Visibility of PPE Stock Levels*. Available at: <https://mezzanineware.com/south-african-national-department-of-health-using-stock-visibility-solution-to-provide-real-time-visibility-of-ppe-stock-levels/> (Accessed: September 22, 2020).

Mthoko, H.L. and Pade-Khene, C. (2013) “Towards a theoretical framework on ethical practice in ICT4D programmes,” *Information Development*, 29(1). doi:10.1177/0266666912449456.

Murphy, J.T. (2001) “J.T. Murphy, Making the energy transition in rural East Africa: Is leapfrogging an alternative?,” *Technological Forecasting and Social Change*, (68), pp. 173–193.

Musango, J.K. *et al.* (2012) “A system dynamics approach to technology sustainability assessment: The case of biodiesel developments in South Africa,” *Technovation*, 32(11), pp. 639–651. doi:10.1016/j.technovation.2012.06.003.

National Department of Health (2015) *National Department of Health: Annual Report 2014/2015*.

National Department of Health (2016) *National Department of Health: Annual report 2015/16*.

National Department of Health (2017) *National Department of Health: Annual Report 2016/2017*.

Negro, S.O. (2007) *Dynamics of Technological Innovation Systems – The case of Biomass Energy*. Utrecht University.

Nelson, R.R. (1993) *National Innovation Systems: A Comparative Analysis*. Oxford University Press.

Ng, B.-K., Kanagasundram, T., Wong, C.-Y. and Chandran, V.G.R. (2016) “Innovation for inclusive development in Southeast Asia: the roles of regional coordination mechanisms,” *The Pacific Review*, 29(4). doi:10.1080/09512748.2015.1022590.

Niosi, J. (2002) “National systems of innovations are ‘x-efficient’ (and x-effective) why some are slow learners,” *Research Policy*, 31(2), pp. 291–302.

Nolting, C.W., Grobbelaar, S.S. and van Vuuren, J.H. (2018) “A Decision Support Tool for Quantifying the Risk Profile of South Africa’s Pharmaceutical Supply Distribution Network South Africa’s Burden of Disease,” in *29th SAIIE Annual Conference*.

Odame, H.S., Okeyo-Owuor, J.B., Changeh, J.G. and Otieno, J.O. (2020) “The role of technology in inclusive innovation of urban agriculture,” *Current Opinion in Environmental Sustainability*, 43, pp. 106–111. doi:10.1016/j.cosust.2019.12.007.

Organisation for Economic Co-operation and Development (OECD) (1997) *National Innovation Systems*. Paris: OECD Publications.

Organisation for Economic Co-operation and Development (OECD/Eurostat) (2005) *Oslo Manual, Guidelines for Collecting and Interpreting Innovation Data*. Paris: OECD Publishing

Peerally, J.A., de Fuentes, C. and Figueiredo, P.N. (2019) “Inclusive innovation and the role of technological capability-building: The social business Grameen Danone Foods Limited in Bangladesh,” *Long Range Planning*, 52(6). doi:10.1016/j.lrp.2018.04.005.

Piketty, T. (2014a) “Dynamics of Inequality,” *New Left Review*.

- Piketty, T. (2014b) “Thomas Piketty: Dynamics of Inequality,” *New Left Review*, 85, pp. 103–116.
- Poole, M.S., Van de Ven, A., Dooley, K.J. and Holmes, M.E. (2000) *Organizational Change and Innovation Processes, Theories and Methods for Research*.
- Prahalad, C.K., Di Benedetto, A. and Nakata, C. (2012) “Bottom of the pyramid as a source of breakthrough innovations,” *Journal of Product Innovation Management*, 29(1), pp. 6–12. doi:10.1111/j.1540-5885.2011.00874.x.
- Prahalad, C.K. and Hart, S.L. (2002) *The Fortune at the Bottom of the Pyramid*. Wharton School Publishing. doi:10.2139/ssrn.914518.
- Quitow, R. (2015) “Dynamics of a policy-driven market,” *Environmental Innovation and Societal Transitions*, 17, pp. 126–148. doi:10.1016/j.eist.2014.12.002 T4 - The co-evolution of technological innovation systems for solar photovoltaics in China and Germany M4 - Citavi.
- Ramadani, L., Kurnia, S. and Breidbach, C.F. (2018) “In Search for Holistic ICT4D Research: A Systematic Literature Review,” in. doi:10.24251/HICSS.2018.304.
- Rodriguez, J.C. and Lenin Navarro Chavez, J.C. (2011) “A science and technology policy model to support regional innovation systems,” *Revista Nicolaita de Estudios Económicos*, 2, pp. 73–85.
- Romer, P.M. (1986) “Increasing returns and long-run growth,” *Journal of Political Economy*, 94, pp. 1001–1037.
- Romer, P.M. (1990) “Endogenous technological change,” *Journal of Political Economy*, 98, pp. 71–102.
- Rothwell, R. (1994) “Rothwell, R. (1994) Towards the Fifth-generation Innovation Process, *International Marketing Review*, Vol. 11 No. 1, 1994, pp. 7-31,” 11(1), pp. 7–31. Available at: <https://es.scribd.com/document/90210128/Rothwell-Towards-the-Fifth-Generation>.
- Samara, E., Georgiadis, P. and Bakouros, I. (2012) “The impact of innovation policies on the performance of national innovation systems: A system dynamics analysis,” *Technovation*, 32(11), pp. 624–638. doi:10.1016/j.technovation.2012.06.002.

Schaber, P. (2011) “Absolute Poverty,” in. doi:10.1007/978-90-481-9661-6_11.

Senge, P.M. (2006) *The fifth discipline*. London: Random House Business Book.

Simanis, E., Hart, S. and Duke, D. (2008) “The Base of the Pyramid Protocol: Beyond ‘Basic Needs’ Business Strategies,” *Innovations: Technology, Governance, Globalization*, 3(1). doi:10.1162/itgg.2008.3.1.57.

Singh, H., Díaz Andrade, A. and Techatassanasoontorn, A.A. (2018) “The practice of ICT-enabled development,” *Information Technology for Development*, 24(1). doi:10.1080/02681102.2017.1283284.

Smith, R. (2019) *A co-creation design framework to support elderly rural women in refining an ICT platform* by. University of Pretoria.

Sonne, L. (2012) “Innovative initiatives supporting inclusive innovation in India: Social business incubation and micro venture capital,” *Technological Forecasting and Social Change*, 79(4), pp. 638–647. doi:10.1016/j.techfore.2011.06.008.

Sterman, J.D. (2000) *Business Dynamics. Systems Thinking and Modeling for a complex world*. Boston: McGraw Hill Higher Education.

Stokey, N.L. (1995) “R&D and Economic Growth,” *The Review of Economic Studies*, 62(3). doi:10.2307/2298038.

Sundbo, J. (1998) *The Theory of Innovation*. Northampton: Edward Elgar.

Suurs, R.A.A. (2009) *Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems (PhD thesis)*, Innovation Study Group, Utrecht University, Utrecht. Universiteit Utrecht. Available at: <http://igitur-archive.library.uu.nl/dissertations/2009-0318>.

Swaans, K., Boogard, B., Bendapudi, R., Taye, H., Hendrickx, S. and Klerkx, L. (2014) “Operationalizing inclusive innovation: lessons from innovation platforms in livestock value chains in India and Mozambique,” *Innovation and Development*, 4(2). doi:10.1080/2157930X.2014.925246.

Thorpe, J., Mathie, A. and Ghore, Y. (2017) *A typology of market-based approaches to include the most marginalised*. Brighton.

Tigabu, A.D., Berkhout, F. and Van Beukering, P. (2015a) “Technology innovation systems and technology diffusion: Adoption of bio-digestion in an emerging innovation system in Rwanda,” *Technological Forecasting and Social Change*, 90(PA), pp. 318–330. doi:10.1016/j.techfore.2013.10.011.

Tigabu, A.D., Berkhout, F. and Van Beukering, P. (2015b) “The diffusion of a renewable energy technology and innovation system functioning: Comparing bio-digestion in Kenya and Rwanda,” *Technological Forecasting and Social Change*, 90(PA), pp. 331–345. doi:10.1016/j.techfore.2013.09.019.

Trojer, L., Rydhagen, B. and Kjellqvist, T. (2014) “Inclusive innovation processes – experiences from Uganda and Tanzania,” *African Journal of Science, Technology, Innovation and Development*, 6(5). doi:10.1080/20421338.2014.970437.

Uriona Maldonado, M. and Grobbelaar, S. (2017) “System Dynamics modelling in the Innovation Systems literature,” *15th Globelics International Conference*, Athens, October.

Uriona Maldonado, M. (2009) “A preliminary framework for modeling innovation systems in Latin America,” *7o Congreso Latinoamericano de Dinamica de Sistemas* [Preprint].

Van de Ven, A.H., Poolley, D.E., Garud, R. and Venkataraman, S. (1999) *The Innovation Journey*. Oxford University Press.

Van der Hilst, B. (2012) *Inclusive innovation systems. How innovation intermediaries can strengthen the innovation system: A case study of Vietnam*. Utrecht University.

Van der Merwe, E. (2017) *Developing an Analysis Framework to Evaluate Inclusive Innovation System Performance*. Stellenbosch University.

Van der Merwe, E. (2018) *Exploring Innovation for Inclusive Development Dynamics from an Innovation Systems Perspective*. Stellenbosch University.

Van der Merwe, E. and Grobbelaar, S. (2018) “Systemic policy instruments for inclusive innovation systems: Case study of a maternal mHealth project in South Africa,” *African Journal of Science, Technology, Innovation and Development*, 10(6), pp. 665–682. doi:10.1080/20421338.2018.1491678.

Van der Merwe, E., Grobbelaar, S. and Bam, W. (2020) “Exploring the functional dynamics of innovation for inclusive development innovation systems: a case study of a large scale maternal mHealth project in South Africa,” *Innovation and Development*, 10(1). doi:10.1080/2157930X.2019.1567884.

Veldsman, A. and Darelle van Greunen, D. (2015) “ICT interventions for socio-economic development — A practitioner’s view,” in *2015 IEEE International Symposium on Technology and Society (ISTAS)*. IEEE. doi:10.1109/ISTAS.2015.7439444.

Ver Loren van Themaat, T., Schutte, C.S.L., Lutters, E. and Kennon, D. (2013) “Designing a framework to design a business model for the ‘bottom of the pyramid’ population,” *South African Journal of Industrial Engineering*, 24(3), pp. 190–204. doi:10.7166/24-3-633.

Vodacom Group (2016) *The Vodacom Foundation - About Us*. Available at: <https://vodacomfoundationsa.co.za/about-us/> (Accessed: October 5, 2020).

Walrave, B. and Raven, R. (2016) “Modelling the dynamics of technological innovation systems,” *Research Policy*, 45(9), pp. 1833–1844. doi:10.1016/j.respol.2016.05.011.

Walsh, V. and Le Roux, M. (2004) “Contingency in innovation and the role of national systems: Taxol and taxotère in the USA and France,” *Research Policy*, 33(9), pp. 1307–1327. doi:10.1016/j.respol.2004.07.009.

Wicki, S. and Hansen, E.G. (2017) “Clean energy storage technology in the making: An innovation systems perspective on flywheel energy storage,” *Journal of Cleaner Production*, 162, pp. 1118–1134. doi:10.1016/j.jclepro.2017.05.132.

Wieczorek, A.J. and Hekkert, M.P. (2012) “Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars,” *Science and Public Policy*, 39(1), pp. 74–87. doi:10.1093/scipol/scr008.

Wieczorek, A.J., Hekkert, M.P., Coenen, L. and Harmsen, R. (2015) “Broadening the national focus in technological innovation system analysis: The case of offshore wind,” *Environmental Innovation and Societal Transitions*, 14, pp. 128–148. doi:10.1016/j.eist.2014.09.001.

Youssefi, H., Nahaei, V.S. and Nematian, J. (2011) “A New Method For Modeling System Dynamics By Fuzzy Logic Modeling Of Research And Development In The National System Of Innovation,” *Journal of Mathematics and Computer Science*, 02(01), pp. 88–99. doi:10.22436/jmcs.002.01.10.

Zheng, Y., Hatakka, M., Sahay, S. and Andersson, A. (2018) “Conceptualizing development in information and communication technology for development (ICT4D),” *Information Technology for Development*, 24(1). doi:10.1080/02681102.2017.1396020.

Appendix A: Event Analysis Tables of Case Studies

Table A-1 Event Analysis Table of Mafarafara Case Study

Event ID	Event	Recognisable activity	Applicable function(s)
1	ICT platform development and testing at similar sites.	Pilot project; feasibility study	F2
2	Research on appropriate community with ERW requirements.	Research	F2
3	Obtain ethical clearance from the necessary research institutes.	Research collaborations	F2
4	Develop ethical procedures and documents, training documents and interview guidelines.	Developing prototypes	F2
5	Pilot the ethical process within a similar community to Mafarafara and finalise the processes and documentation according to the results of the pilot study.	Pilot project; feasibility study	F2
6	Prepare for initiation of project by sending information about the project and explaining the processes to be followed for Mma C to read.	Development of knowledge channels between informal and formal sector actors; Defining expectations; Communicating vision	F3, F4
7	Under the leadership of Mma C, the ERW agree in principle to commence with ICT project.	Opportunities for marginalised partake in entire innovation development	F1
8	Mma C sanctions the initial project with the ERW.	Engagement with marginalised groups and forming trustworthy relationships	F7

9	Research team arrive at community and enjoy dinner together that Mma C prepared.	Engagement with marginalised groups and forming trustworthy relationships	F7
10	Mma C states that she is not clear on the purpose of research team's visit. The team elaborate on their intentions citing documents previously sent to Mma C and again explains the project.	Defining expectations; Communicating vision	F4
11	Research team joins Mma C and visit the chief of the village through which they obtain his blessing on the project.	Engagement with marginalised groups and forming trustworthy relationships; Promises	F4, F7
12	First meeting with the ERW and introductions are made.	Conferences, workshops, seminars and meetings	F3
13	ERW do not understand what ICT platform would be like and the research team explains what it is, how it works and answers questions raised by ERW.	Creation of platforms for informal and formal sector actors to engage; Defining expectations, Promises, Communicating vision	F3, F4
14	Research team explains ethical consent process and the consent forms are signed.	Creation of platforms for informal and formal sector actors to engage	F3
15	Research team uses the remainder of the visit to engage with the ERW and build meaningful relationships with them.	Engagement with marginalised groups and forming trustworthy relationships	F7
16	Research team visit crop fields of the community. They use the crops as resources, but sometimes suffer as a result of lack of irrigation.	-	None
17	Second meeting of visit with ERW and information are gathered on	Considerations of literacy, capabilities and capacity of	F2

	women's livelihoods, previous exposure to technology and farming information.	marginalised groups in design and development of innovations	
18	Visit and assess potential site of installation of technology and solar panels.	Feasibility studies	F2
19	Conduct a pre-installation technical site survey to identify and mitigate possible obstacles for installation and determine best location to install technology.	Market surveys	F2
20	Install ICT platform with help of the ERW and two young men.	Acquiring technological infrastructure	F6
21	The information that are uploaded onto the ICT platform are according to the informational needs expressed by the target audience during the first visit and consist of other standard information for DD projects.	Formal knowledge focus on marginalised livelihoods	F2
22	Visit chief and provide update of ICT platform project to him.	Engagement with marginalised groups and forming trustworthy relationships, Defining expectations, Promises	F4, F7
23	The ERW are briefed on informed consent and the research team makes it clear than anyone is welcome to participate in the project in order to value inclusivity. The project is explained to new participants.	Creation of platforms for informal and formal sector actors to engage; Communicating vision	F3, F4
24	During a lunch break, the research team share some of their juice and biscuits they brought along with the	-	None

	ERW, but it is not enough for everyone.		
25	Training activities are started but some of the ERW are not present because they have to collect their monthly pension grants. The two young men who assisted with the installation of the ICT platform help facilitate training by explaining the content in the ERW's home language which is Sepedi.	Training activities; Using marginalised actors as distributors of knowledge within the marginalised community	F3
26	Small group interviews are held to determine ERW's livelihoods, farming problems and information needs, while other received training. From the interviews it is gathered that the greatest need among the community is to have proper irrigation infrastructure for crop fields. Without it, the agriculture information would not be of much use.	Forms of training and development provided to marginalised groups	F3
27	Training is continued from the previous day and the ERW are taught how to log into system, accessing their own folders and information about farming.	Training activities	F3
28	Mma C is encouraged to identify people who she can mentor to fulfil the role of her assistant. Two young men who assisted with the installation of the ICT platform are trained to assist and provide maintenance and technical support.	Using marginalised actors as distributors of knowledge within the marginalised community; Recruiting human resources (including	F3, F6

		consultants and technical staff)	
29	The system of the ICT platform is modified by adjusting font size to help some ERW who suffer from poor eyesight to see the text clearer.	Emphasis on ability of diffusion of important information to enhance I4ID	F3
30	Group discussions are held and the research team gets feedback on ERW's usage of the platform.	Development of knowledge channels between informal and formal sector actors	F2
31	ERW say they have learned valuable things, especially related to crop and livestock farming and that they enjoy using the platform.	Build legitimacy around the effect of interventions within marginalised groups; Enhancing belief in the potential of a project	F4, F7
32	The ERW ask for more information on agricultural content in their own language (Sepedi) and this is attended to during the next technical visit.	-	None
33	During the discussions, ownership, personal responsibility and empowerment among the ERW are highlighted.	Defining expectations	F4
34	The research team brings food and share with participants, something they appreciate a lot.	Engagement with marginalised groups and forming trustworthy relationships	F7
35	Training activities are held and a personal profile on the ICT platform is created for each of the participating women.	Training activities	F3
36	Research team visits neighbouring town's agricultural office to inquire if the office could help the Mafarafara	Providing directions or showing interest	F4

	community, especially with irrigation, but the visit is not successful.		
37	Upgrade solar panels forming part of ICT platform to enhance battery life.	Acquiring technological infrastructure	F6
38	Update information base of ICT platform that addresses information requests expressed by women during previous visits.	Development of knowledge channels between informal and formal sector actors	F2
39	Upon arrival, the research team hands out porridge meal and vegetables that they brought along. The ERW ration the food so that it can be eaten over two days.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
40	The ERW express their worry about the change in composition of the research team and their desire to keep the team the same. (It is clear they value relationships that have developed.)	Negative effect for "Engagement with marginalised groups and forming trustworthy relationship" (F7)	None
41	At the start of the second day, a visit to the chief is conducted once again.	Engagement with marginalised groups and forming trustworthy relationships	F7
42	Visit is made to the crop garden.	-	None
43	Two funerals in neighbouring communities stall the planned activities of the day since most members of the ERW attended the funerals.	Blocking for "Training Activities" (F3)	
44	ERW are confused about the role of the two young men previously trained: the men expected without it ever being stated that they will be paid.	Negative effect for "Defining expectations" (F4)	None

45	Individual interviews with 11 ERW are held to gain insight into their experience of using the ICT platform. They request new information to be added onto the ICT platform that are especially health and agriculture related.	Focussing on knowledge, development and collaboration	F2
46	During the interviews, the ERW also express their positivity towards the project and feel proud that they are able to use the ICT platform.	Build legitimacy around the effect of interventions within marginalised groups	F7
47	The rest of the community approve the use of the ICT platform because they recognise the benefits for the ERW.	Build legitimacy around the effect of interventions within marginalised groups; Enhancing belief in the potential of a project	F7
48	Research team makes a second visit to the agricultural office and convinces two officials to visit Mafarafara. Upon their visit, they sanction help for the Mafarafara community.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
49	Upon arrival the ERW express their desire towards the research team to have visited earlier. They do concede however, that this would not have been possible as they were very busy with assisting an initiation school which Mma C organised.	-	None
50	As a result of the initiation school, the ERW did not use the ICT platform very often since the last visit, except for the week leading up to the fifth	Blocking for "Emphasis on ability of diffusion of important information to enhance I4ID" (F3)	None

	research visit when the school was finished.		
51	During a debrief session, an issue is uncovered: A male researcher held interviews with women at their houses during fourth visit to promote better social relationships, in the process upsetting some of the ERW's husbands.	Negative effect for "Engagement with marginalised groups and forming trustworthy relationship" (F7)	None
52	Excluding the time spent on the initiation school, according to the ERW the usage of the ICT platform has become part of their daily rituals.	Emphasis on ability of diffusion of important information to enhance I4ID	None
53	Through observation the ERW assist one another when using the ICT platform.	Using marginalised actors as distributors of knowledge within the marginalised community	F3
54	The two young men who were trained as assistants still assist the ERW too by switching the platform on and taking care of technical tasks	Using marginalised actors as distributors of knowledge within the marginalised community	F3
55	As part of the project's exit strategy, the ERW are told that they will become responsible for maintenance of the platform in the future.	-	None
56	ICT platform is removed for technical maintenance and updates.	Negative effect for "Acquiring technological infrastructure" (F6)	None
57	System is updated to include information related to health, agricultural, lightning and thunderstorms, patterns for clothing,	Focussing on knowledge, development and collaboration	F2

	ideas on crafts, simple accounting program, educational stories.		
58	Infrastructure added are a printing/photocopying facility for whole community and chairs for when working on platform so that they won't get tired while standing.	Acquiring technological infrastructure; Providing equipment	F6
59	Upon arrival, it is once again mentioned that the ERW do not like changes in the composition of the research team.	Negative effect for "Engagement with marginalised groups and forming trustworthy relationship" (F7)	None
60	The remainder of the day is spent gathering an understanding of the diffusion of the project among the community and continuing to build relationships by finding out more about the village and the lives of the people.	Focussing on knowledge, development and collaboration; Engagement with marginalised groups and forming trustworthy relationship	F2, F7
61	Individual interviews with 11 ERW are held to gain insight into their experience of using the ICT platform and the informed consent procedures is briefly covered again.	Focussing on knowledge, development and collaboration	F2
62	From the interviews it is gathered that a core group of the ERW regularly use the platform and that among the core group a belief exist that they are part of a select group and as a result feel empowered.	Build legitimacy around the effect of interventions within marginalised groups	F7
63	ICT platform is re-installed and women express that they have missed it while it was gone.	Acquiring technological infrastructure	F6

64	ERW all require renewed training to be able to operate ICT platform.	Training activities	F3
65	Printer is installed and since research team is not responsible to buy ink cartridges etc. the ERW are told to charge people using the printer.	Acquiring technological infrastructure	F6
66	ERW express their desire to upgrade and renovate the current community centre.	-	None
67	Community centre was damaged due to a storm and could not be used, but platform remained protected	Negative effect for "Infrastructure developments" (F6)	None
68	Interviews are held to get an idea of the experience of the women after the platform cannot be used anymore.	Focussing on knowledge, development and collaboration	F2
69	From conversations with ERW it is gathered that the ICT platform upgrades along with the printer increased motivation and usage among core group of users and they believe their position were better than ever before.	-	None
70	Damage to centre cause the research team to seek for new location and no new location is found. Thus the project is put on hold.	Blocking for "Infrastructure developments" (F6)	None
71	Community starts fundraising campaign for a new community centre.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
72	For the first time ERW are willing to take responsibility for maintenance of ICT platform.	Incentives for successful scaling of programme or innovation encouraging	F6

		local entrepreneurs to actively take part	
73	Technical site inspection is conducted to assess progress of new building and it is found that a new building has been built.	Infrastructure developments	F6
74	ICT platform and printer was still intact, but platform needs upgrading since technology aged since 2013 and solar panel battery needs replacing.	Blocking for "Acquiring technological infrastructure" (F6)	None

Table A-2 Event Analysis Table of ICT4RED Case Study

Event ID	Event	Recognisable activity	Applicable function(s)
1	Obtain ethical approval from relevant research institution and governmental authorities.	Research collaborations	F2
2	Conduct thorough literature review to see why similar cases previously failed or successfully scaled and identify if other frameworks, models etc. exist that can be used in the (ICT4RED) initiative and development framework.	Academic research	F2
3	One specific framework identified through research is adapted and used as the implementation model to guide the implementation of the initiative and important processes throughout.	Conceptualising intervention models	F2

4	Final components of the additional implementation model for the ideal 21st century school setting is identified through further research and consultation with experts.	Academic research	F2
5	For each of the identified components, a champion for each is selected within the research team to make up the core ICT4RED research team.	Recruiting human resources (including consultants and technical staff)	F6
6	Weekly meetings are held to track progress and get feedback from each component and see where integration between the components are necessary.	Research Collaborations	F2
7	The first artefact is designed.	Developing prototypes	F2
8	Undertake a technology scan to establish whether tablets or e-readers should be used for the initiative.	Feasibility studies	F2
9	Department of Basic Education decides it is best to deploy low-cost tablets and they are acquired.	Acquiring technological infrastructure	F6
10	The pilot project at a secondary school is started.	Pilot projects; Opportunities for marginalised partake in entire innovation development	F2, F1

11	The initiative is explained to governmental officials to obtain their support.	Communicating vision; Advocacy coalitions	F4, F7
12	Members of the ICT4RED team meet with the chief of community where the school is situated. The project is explained to him and he gives the team his blessing and support for the project.	Engagement with marginalised groups and forming trustworthy relationships; Communicating vision, Promises	F4, F7
13	The leaders at the school (principal, deputy-principal and governing body) are met with through various meetings to explain the initiative and obtain buy-in from their side.	Engagement with marginalised groups and forming trustworthy relationships; Communicating vision, Promises	F4, F7
14	An ICT champion is assigned to the school to do novel tasks and support teachers where necessary once the school starts to implement the usage of technology within their teachings later on in the phase.	Recruiting human resources (including consultants and technical staff)	F6
15	The principal, deputy and previously identified ICT champion attend a workshop where they receive the necessary training. Afterwards they receive homework to complete.	Training activities	F3

16	Literature is consulted and combined with what is known from practice to develop training strategies and material for the training program to be offered to the teachers	Academic research	F2
17	Teachers receive training (Teacher Professional Development) equipping them with the necessary skills to be able to use ICTs while teaching. Afterwards they too receive homework to complete.	Training activities	F3
18	Teachers complete TPD and they, along with the school receive the previously acquired tablets to use.	Acquiring technological infrastructure/Providing equipment	F6
19	Supporting technological infrastructure is installed.	Alignment of resources to needs of the system	F6
20	Learners are handed tablets, which they begin to use.	Learning by using	F2
21	An ICT committee is selected and appointed within the school to govern operational management and technical support. The committee is responsible for deciding the usage of the tablets per grade, class and subject.	Recruiting human resources (including consultants and technical staff)	F6

22	At the conclusion of the phase, self-evaluation reports are given to teachers and learners, district officials, community leaders and implementers of the initiative to complete providing important feedback for improved design.	Using marginalised actors as knowledge providers	F2
23	Meetings with principals and teachers are held to obtain their feedback for what worked and what did not.	Using marginalised actors as knowledge providers	F2
24	Further feedback related to Wi-fi, routers and lockers are given from the role players in the school.	Using marginalised actors as knowledge providers	F2
25	The lessons, feedback and results from the phase are synthesised, resulting in the adaption of the implementation model which now consist of 12 components instead of the initial seven.	Adapting model	F2
26	Additional project champions for each new component is selected and they form part of the core research team of the initiative.	Recruiting human resources (including consultants and technical staff)	F6

27	Ethnographic study is done a year before and a year after the tablets were given to teachers and the results is compared. It shows that positive behavioural changes was made, by teachers and learners alike.	Testing of model performance; Build legitimacy around the effect of interventions within marginalised groups	F2, F7
28	During Phase 1, teachers were given 7-inch low-cost tablets. This is replaced with 10-inch branded tablets for Phase 2 and 3.	Acquiring technological infrastructure/Providing equipment	F6
29	Suitable content is sourced and uploaded onto the tablets so that the tablets can be used when internet connectivity is unavailable.	Studies, Focussing on knowledge, development and collaboration	F2
30	The initiative is expanded to include 11 new schools.	Opportunities for marginalised partake in entire innovation development	F1
31	Meetings with district officials, government stakeholders are held to explain the initiative and obtain buy-in and establish trustworthy relationships.	Communicating vision; Advocacy coalitions	F4, F7
32	Government stakeholders come up with a Memorandum of Understanding providing clarity on roles and responsibilities.	Government policies oriented toward inclusive development	F5

33	The memorandum deems that district officials are assigned as resources for the initiative and are to be included in decision making.	Recruiting human resources (including consultants and technical staff)	F6
34	Meetings with principals and deputies from new schools are held to explain the initiative and obtain buy-in.	Communicating vision, Promises; Engagement with marginalised groups and forming trustworthy relationships	F4, F7
35	Training is given to the principals and deputies related to change management to be able to manage the transition from traditional to technology-based learning within a school setting. They are given homework to complete.	Training activities	F3
36	Training material for district officials are developed based on feedback from teachers who took part in Phase 1.	Focussing on knowledge, development and collaboration	F2
37	Workshop for District Officials are held to provide the training for them to offer the necessary support and they receive homework to complete.	Training activities	F3
38	With the focus on change management, district officials offer support by	Special governmental efforts to develop environments that support I4ID and to prepare the	F5

	preparing schools to use and manage the technology within the school environment.	market for successful uptake of innovation	
39	Earn as you learn approach is developed where a badging system ensures that work is done first to obtain technology, thereby strengthening the belief among teachers and learners that they are part of the initiative.	Policies formed to enhance empowerment and capabilities of marginalised groups	F4
40	Teachers from various schools start the TPD training.	Training activities	F3
41	Teachers quickly become used to using the devices.	Learning by using	F2
42	Teachers initiate their own study groups after school to earn badges and technology for their schools.	Using marginalised actors as distributors of knowledge within the marginalised community	F3
43	All teachers enrolled to the training program graduate and the schools are determined to be ready.	Recruiting human resources (including consultants and technical staff)	F6
44	Teachers complete TPD and they, along with the school receive the previously acquired tablets to use.	Acquiring technological infrastructure	F6
45	Supporting technological infrastructure is installed.	Acquiring technological infrastructure	F6

46	An ICT committee is selected and appointed within the school to govern operational management and technical support. The committee is responsible for deciding the usage of the tablets per grade, class and subject.	Recruiting human resources (including consultants and technical staff)	F6
47	Teachers become more competent in using the tablets and technology when teaching. Learners start to use the tablets in class.	Learning by using	F2
48	Some schools struggle to implement the technology effectively as a result of internal educational and management issues.	Negative effect for "Manufacturing and/or constructing and/or installing technology" (F1)	None
49	Feedback is gathered from the various participants of this phase.	Using marginalised actors as knowledge providers	F2
50	Throughout the initiative the district officials remain very committed to assist the teachers and schools where possible. As a result trustworthy relationships between the school personnel and district officials forms.	Engagement with marginalised groups and forming trustworthy relationships	F7
51	Based on the feedback, outcomes and observations during this phase, the	Adapting model	F2

	implementation model is further developed by explaining and demonstrating the relationships among the components. As a result the model is converted to a framework and is now called the ICT4RED Implementation Framework.		
52	Prior to the implementation of the initiative at the start of Phase 3, it is decided to extend the role of the district officials to be practically involved during more steps of the coming phase.	-	None
53	Phase 3 starts as the initiative is expanded to 14 new schools in addition to the 12 schools involved in the previous phase.	Opportunities for marginalised partake in entire innovation development	F1
54	Meeting with new district officials are held to explain the initiative and obtain buy-in.	Advocacy coalitions; Communicating vision	F4, F7
55	The ICT4RED team approaches overseers of the National Rural Youth Service Corps (NARYSEC) programme to work together during the remainder of the initiative.	Advocacy coalitions; Communicating vision	F4

56	The youth of the NARYSEC programme become part of the ICT administrator team of the initiative to fulfil the roles of ICT champions within the new schools where the initiative is implemented.	Recruiting human resources (including consultants and technical staff)	F6
57	Members of the ICT4RED team meet with principals and deputies from new schools to explain the initiative and obtain buy-in.	Communicating vision, Promises; Engagement with marginalised groups and forming trustworthy relationships	F4, F7
58	Training is given to the principals and deputies related to change management to manage technology within a school setting and they receive homework to complete.	Training activities	F3
59	ICT champions are assigned to schools to assist the teachers where required.	Recruiting human resources (including consultants and technical staff)	F6
60	A workshop is held for the ICT champions and district officials and together they receive training focussing primarily on change management. District officials receive additional training enabling them to assist with facilitation of the TPD to be held.	Training activities	F3

61	Teachers start with the TPD training program and the earn-as-you-learn approach is once again used, similar to Phase 2.	Training activities; Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation	F3, F4
62	Refreshment courses for teachers that formed part of Phase 1 and 2 are held.	Training activities	F3
63	While the TPD is still ongoing, some teachers start to collaborate with one other teachers, co-creating content to be used when teaching with technology.	Using marginalised actors as knowledge providers	F2
64	Internal ICT committees within some schools are established to help teachers co-create content and share it with other teachers.	Recruiting human resources (including consultants and technical staff)	F6
65	Change management and leadership courses are held for the teachers and upon finishing these courses, the TPD is concluded.	Training activities	F3
66	Tablets are distributed to the schools.	Acquiring technological infrastructure	F6
67	Supporting technological infrastructure is distributed to the schools and are installed.	Acquiring technological infrastructure	F6
68	Additional learning material continues to be created by teachers.	Using marginalised actors as knowledge providers	F2

69	With the help of the ICT committees, the teachers share their co-created material and they, along with others, start to use the material in their teachings: They start to create and share videos in classes, regularly download new content from the content server and do online assessments.	Using marginalised actors as distributors of knowledge within the marginalised community	F3
70	Some teachers share how the change from traditional teaching methods to teaching with technology has significantly impacted the attitude of learners in a positive manner. They also share that the attention span of learners have improved.	Using marginalised actors as knowledge providers; Build legitimacy around the effect of interventions within marginalised groups	F2, F7
71	The teachers' attitude towards ICT learning and teaching with technology has significantly improved as they become more comfortable using it during their teachings.	Build legitimacy around the effect of interventions within marginalised groups	F7
72	The schools report how the initiative has brought forth a positive change in actions from the side of the district leaders since its initiation and has resulted in improved	Build legitimacy around the effect of interventions within marginalised groups	F7

	relationships between them and these officials.		
73	The ICT4RED team starts a blog that allows them to communicate their findings and developments of the initiative on an online platform.	Demonstrations/Seminars; Communicate research outcomes to the public; Build legitimacy around the effect of interventions within marginalised groups	F3, F4
74	Upon invitation, members of the ICT4RED team attend local and international gatherings among practitioners specialising in ICT within education. The team share their findings of the initiative at the gatherings.	Demonstrations/Seminars; Communicate research outcomes to the public; Build legitimacy around the effect of interventions within marginalised groups	F3, F4
75	The ICT4RED team informs the relevant stakeholders of the Cofimba school district (district officials and Eastern Cape Department of Education officials) that they need to develop a sustainability plan and strategy to ensure that the initiative continues in a lasting and sustainable manner.	-	None
76	Governments from other provinces in South Africa approach the ICT4RED team to use their training	Special governmental efforts to develop environments that support I4ID and to prepare the	F5

	resources for teachers of their provinces with the plan to ultimately expand the initiative to other schools in their regions	market for successful uptake of innovation	
77	Students from various research institutes start to use the initiative in their studies	Joint ventures; Academic research; Build legitimacy around the effect of interventions within marginalised groups/Provide evidence for benefit of interventions for both formal actors and marginalised groups	F2, F3
78	The final ICT4RED Implementation Framework is established.	Adapting model	F2
79	The initiative is handed over to stakeholders to manage the project further and expand it to other districts and provinces.	Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation	F5

Table A-3 Event Analysis Table of SVS Case Study

Event ID	Event	Recognisable activity	Applicable function(s)
1	The Vodacom Foundation makes funding available to the NDoH to support the department with the nationwide problem of stock outs of TB medicine, vaccines and ARV drugs.	Inclusion of marginalised community within business models; Subsidies (i.e. sharing cost of investment)	F1, F5

2	Vodacom approach Mezzanine to collaborate and work together to develop a solution to the stock-out problem.	Entry of firms	F1
3	Relationships between Mezzanine, Vodacom and the NDoH are established to form a public-private partnership (PPP) network.	Alliances between actors	F3
4	Collaboration between Mezzanine and Vodacom takes place to come up with design of the solution and name it the Stock Visibility Solution.	Providing directions or showing interest; Focussing on knowledge, development and collaboration	F2, F4
5	The design of the SVS is proposed to the NDoH after which the support of the SVS is gained directly from the Minister of Health of South Africa by Mezzanine.	Demonstrations; Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation	F3, F5
6	The government negotiate with Mezzanine and Vodacom to start with a trial period (i.e. PoC phase) that serve as a pilot before they decide to use the SVS as a solution.	Pilot projects	F2
7	The government state that they seek evidence that demonstrate the effectiveness of the solution. According to them, enough evidence would be if the solution successfully	Setting clear and achievable targets	F4

	scales within at least 200 different health facilities.		
8	Vodacom partly finances the PoC phase.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
9	The rest of the funding is provided by seed donors.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
10	The digital tools necessary for the SVS are supplied by Mezzanine.	Acquiring technological infrastructure	F6
11	Vodacom supplies connectivity, the mobile devices that are used by the health officials and a “helpdesk” that provides first line technical support.	Acquiring technological infrastructure	F6
12	The Supply Chain Technical Assistance unit (a unit within the NDoH) are responsible for the implementation of the SVS and other operational management duties.	Alignment of resources to needs of the system	F6
13	The solution is implemented within 605 public health facilities in the Kwazulu-Natal province of South Africa.	Pilot projects; Inclusion of marginalised community within business models/Opportunities for marginalised partake in entire innovation development	F1, F2

14	The pilot is extended by implementing it within two additional provinces.	Pilot projects; Inclusion of marginalised community within business models/Opportunities for marginalised partake in entire innovation development	F1, F2
15	Workshops are held by members of Mezzanine for the relevant members of the NDoH and members of other ministries of health (MoH) staff to explain the solution and equip them to be able to do their operational and management duties.	Communicating vision; Advocacy coalitions	F4, F7
16	During the workshops, they receive training and are encouraged to lead decision making processes.	Training activities	F3
17	The workshops have a positive effect on the members that attend it and they start to take interest in the solution.	Engagement with marginalised groups and forming trustworthy relationships	F7
18	The managers at facility level are chosen as champions for the new initiative.	Alignment of resources to needs of the system	F6
19	Mezzanine consult a field expert to help with training.	Recruiting human resources (including consultants and technical staff)	F6
20	Two training manuals are developed, one for the app and one for the web interface.	Focussing on knowledge, development and collaboration	F2

21	Training days take place where various district, sub-district and facility representatives receive training as presented by the field expert.	Training activities	F3
22	The different facility representatives each receive copies of the two manual plus a poster that can be put up at the facility to explain the process of the solution.	Development of knowledge channels between informal and formal sector actors	F3
23	The facility representatives are given the role of champions for the SVS at the facilities where they are involved at.	Alignment of resources to needs of the system	F6
24	The solution becomes in use at facilities.	Learning by using; Using marginalised actors as distributors of knowledge within the marginalised community	F2, F3
25	The solution scales at the required amount of health facilities and this reassures the relevant NDoH about the technical viability and feasibility of the solution. This in turn helps them to strengthen the “business case” for the Treasury for funding which will give the green light for the initiative to be implemented nationally	Enhancing belief in the potential of a project; Build legitimacy around the effect of interventions within marginalised groups	F4, F7

26	The Treasury approves the usage of the SVS as a mobile solution and it is licenced to the government.	Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation	F5
27	The NDoH start to fully finance the SVS.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID	F6
28	In addition to the licencing payment, the government funds the acquisition of a smartphone with a SIM card for each facility, 10 percent buffer stock and a training fee.	Generating financial and other supporting mechanisms to support marginalised actors involved in realising I4ID; Acquiring technological infrastructure	F6
29	Managers from all the different levels of management are approached to obtain buy-in for the initiative. Mezzanine makes a conscious effort to build relationships with these people of management. They explain in-depth the potential benefit that the solution will offer.	Communicating vision; Advocacy coalitions/Engagement with marginalised groups and forming trustworthy relationships	F4, F7
30	The management state that they are invested in the initiative and their support as champions for the initiative is secured. This greatly helps to enhance belief in the potential	Build legitimacy around the effect of interventions within marginalised groups; Alignment of resources to needs of the system	F6, F7

	of the initiative and set market objectives.		
31	The champions provide very necessary support during the implementation process of the SVS within the various health facilities.	-	None
32	The role of the champions are extended to oversee the change management processes within the facilities that they are responsible for.	Alignment of resources to needs of the system	F6
33	Training days are held where various district, sub-district and facility champions receive training as presented by the field expert mentioned during the PoC phase.	Training activities; Recruiting human resources (including consultants and technical staff)	F3
34	The NDoH set clear goals for the roll-out of the solution.	Setting clear and achievable targets;	F4
35	The solution is integrated into the national health system and becomes functional in the public health facilities.	Learning by using; Using marginalised actors as distributors of knowledge within the marginalised community	More than one
36	This rapid expansion unfortunately leads to unwanted consequences: Change management and training are neglected in order to ensure mass roll-out of the solution and as a result, the	Conducting impact analysis; Blocking effect for "Emphasis on ability of diffusion of important information to enhance I4ID" (F3)	F2

	solution is poorly adopted within many facilities.		
37	Many managers receive training for the second time.	Training activities	F3
38	As the nationwide implementation phase develops, it is realised that a clear governance structures are absent and as a result, users of the SVS are confused and the sense of ownership.	Using marginalised actors as knowledge providers; Blocking effect for "Emphasis on ability of diffusion of important information to enhance I4ID" (F3)	F2
39	In response to the lack of clear governance structures, facility managers are engaged with to explain the benefits of the SVS by enhancing their understanding of the processes and challenges typically faced when managing a medicine supply chain.	Communicating vision; Emphasis on ability of diffusion of important information to enhance I4ID	F3, F4
40	Mezzanine adapt the SVS dashboards to suit the reporting design previously used. This leads to increased usage of the solution.	Adapting model	F2
41	An independent company specialising in supply chain management is approached to work with the government to help manage the solution from a supply chain perspective.	Recruiting human resources (including consultants and technical staff)	F6

42	Members of the NDoH and the independent company work together and adapt the existing SVS model to utilise the raw data in an improved manner.	Adapting model	F2
43	A top-down mandate is implemented by the NDoH to enhance the accountability within the relevant structures in order to improve the usage of the solution.	“Obligatory use”	F5
44	A weekly cut-off time to submit reports is introduced to which facilities must adhere to.	Reforming regulations	F5
45	It is noted that when some facility managers receive low- or no-stock notifications for the facilities that they are responsible for, they initially do not know what to do.	Using marginalised actors as knowledge providers; Blocking effect for "Emphasis on ability of diffusion of important information to enhance I4ID" (F3)	F2
46	The NDoH develops a comprehensive Standard Operating Procedure (SOP) document to implement the SVS that stipulate the requirements and expectations of the users of the solution for all levels within the health system.	Focussing on knowledge, development and collaboration; Defining expectations/Setting clear and achievable targets	F2, F4
47	The SVS app is adapted by integrating it with existing	Adapting model	F2

	stock ordering software that is already used upstream by ministries of health to make it easier to reorder stock.		
48	Some users of the solution at facility level feels that steps that are set out in SOP document do not align with their job requirements and they feel that there is a lack of communication from managerial authorities.	Using marginalised actors as knowledge providers; Blocking effect for "Emphasis on ability of diffusion of important information to enhance I4ID" (F3)	F2
49	WhatsApp is used to create groups where users of the platform can communicate. It is primarily used among facility managers and their sub-district and district managers where the latter offer advice, provide important information and support the users under their care.	Development of knowledge channels between informal and formal sector actors	F3
50	Incorrect stock reports are sent to management that contain stock that are not even available at the specific facilities. Unique formulary list are developed in the app for each health facility to help SVS users to do proper stock reports of the stock dispensed from their specific facility.	Adapting model	F2

51	Pharmacy assistants (PAs) are introduced at some facilities to lessen the workload.	Recruiting human resources (including consultants and technical staff)	F6
52	Feedback from users of the SVS is gathered after the national roll-out and implementation phase. Users and managers do not recognise the benefit of the solution, since they feel it adds to their workload.	Using marginalised actors as knowledge providers	F2
53	In response to the feedback, Mezzanine starts to use a user-centred design approach that changes the user's perspective of the solution to a pleasant and smooth using experience.	Adapting model	F2
54	Renewed groups discussions are held to get further feedback and 16 PAs are interviewed.	Using marginalised actors as knowledge providers	F2
55	The PAs all state independently that the SVS mobile app is easy to use. They also state that the SVS is quicker than the previous manual method used to report on stock.	Build legitimacy around the effect of interventions within marginalised groups	F7
56	Fifteen of the sixteen interviewees view the SVS as a good initiative, because it ensures availability of stock at the various facilities.	Build legitimacy around the effect of interventions within marginalised groups	F7

57	It is also reported that the solution has had a positive influence on PAs and nursing staff at the healthcare by encouraging them to perform their required tasks.	Build legitimacy around the effect of interventions within marginalised groups	F7
58	They also state that they feel motivated and that “the application is simple, straightforward and easy to use”.	Build legitimacy around the effect of interventions within marginalised groups	F7
59	The SVS is added to the ideal clinic assessment list. The ideal clinic assessment list is part of the “Ideal Clinic Programme”.	Special governmental efforts to develop environments that support I4ID and to prepare the market for successful uptake of innovation; Setting clear and achievable targets	F4, F5
60	The addition of the SVS to the list, results in increased compliance among healthcare facilities. It also results in the building of working partnerships between PHC- and pharmaceutical management.	Build legitimacy around the effect of interventions within marginalised groups/Engagement with marginalised groups and forming trustworthy relationships	F7
61	Students from different education facilities start to use the solution in their tertiary studies.	Academic research	F2
62	In-depth interviews are held again during 2019 with participating healthcare workers of the SVS program.	Using marginalised actors as knowledge providers	F2

63	Concerns are raised about the effectiveness of the program to address the fundamental problem of stock-outs of medication (such as immunizations and vaccines) in certain facilities in rural areas.	-	None
64	It is also time consuming and adds to the already-heavy workload of the workers in facilities where PAs are not employed.	-	None
65	The ability to track important information, such as stock availability and expiration dates, and the enablement to redistribute stock levels are praised.	Build legitimacy around the effect of interventions within marginalised groups	F7
66	Participants give suggestions to address the issues that they encounter.	Using marginalised actors as knowledge providers	F2
67	The interviewers state that the health workers are committed to the solution to ensure the availability of important medication.	Communicate research outcomes to the public; Build legitimacy around the effect of interventions within marginalised groups	F4, F7