The Evaluation of Innovation for Inclusive Development Projects

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DECLARATION

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ABSTRACT

Innovation for inclusive development aims to not only produce products and services for base of the pyramid (BoP) markets, but also to improve innovative capacity and empower those in marginalised communities. Although a wide range of actors aim to support innovation for inclusive development, they lack proper methods to assess the impact that these projects have. This study sets out to develop a framework and tool to guide the evaluation of University-driven Technology-based Innovation for Inclusive Development (UTIID) projects in order to evaluate performance, identify weaknesses and classify project outcomes.

A systematic literature review is conducted to identify an evaluation approach from the extant literature that may best be able to evaluate UTIID projects. Based on the review, a process-level, innovation system (IS) approach, namely the component-function approach is identified as the most appropriate approach for the evaluation of UTIID projects. This approach is focused on the components within a system and the changes that occur through the interaction of the components in the system functions.

An empirical study is conducted on 16 UTIID projects from four different universities in the Western Cape region of South Africa. These case studies are used for several purposes (1) to investigate the current state of monitoring and evaluation in UTIID projects; (2) to map the inputs, outputs and outcomes of these projects in order to construct a typology; and (3) to validate the use of the component-function approach as an UTIID project evaluation approach.

The empirical findings reveal that there are no incentives for UTIID projects to perform outcome evaluations. Several inputs, outputs and outcomes were identified for the studied UTIID projects and these were synthesised into a typology. The application of the component-function analytical framework to the 16 UTIID projects indicated that the component-function analytical framework was an effective method to evaluate the system performance, identify system weaknesses and to propose tools to address the systemic weaknesses within UTIID projects.

Lastly, the developed typologies and component-function analytical framework are used to assemble an UTIID project evaluation tool that enables the evaluation of UTIID projects at a systems level and classify project outcomes.

OPSOMMING

Inklusiewe innovasie beoog nie net om produkte en dienste aan gemarginaliseerde gemeenskappe en die basis van die piramidemark te verskaf nie, maar ook om hul te bemagtig en kapasitiet vir innovasie te verhoog. Alhoewel innovasie rolspelers daarna streef om inklusiewe innovasie te bevorder, is daar ‘n tekort aan voldoende metodes wat gebruik kan word om die impak van inklusiewe innovasieprojekte te evalueer. Die doel van die studie is om ‘n raamwerk en gereedskap te ontwikkel om innovasie-vir-inklusiewe-ontwikkeling projekte wat deur universiteite geloods word, en spesifiek fokus op tegnologiese innovasie, te evalueer en uitkomstes te klassifiseer. In die studie vewys ons na dié projekte as UTIID projekte.

‘n Sistemiese literatuurstudie is uitgevoer om ‘n evaluasiemetode waarmee UTIID-projekte geëvalueer kan word uit die bestaande literatuur te identifiseer. Die innovasiesisteem “component-function” metode is geïdentifiseer as die mees toepaslike metode. Hierdie metode fokus op die komponente in die sisteem en op die verandering wat plaasvind as gevolg van die interaksie tussen die komponente in die sistemiese funksies.

‘n Empiriese studie is toegepas op 16 UTIID- projekte van vier verskillende universiteite in die Wes-Kaap, Suid Afrika. Die gevallestudies vervul verskeie doelwitte nl. (1) om die kwaliteit van evaluasie in huidige UTIID- projekte vas te stel; (2) om die insette, uitsette en uitkomstes van die projekte te identifiseer en sodoende ‘n tipologie op te stel; en (3) om die gebruik van die “component-function” metode vir die evaluasie vir UTIID- projekte te valideer.

Die empiriese bevindinge bewys dat daar geen aansporings is vir UTIID- projekte om uitkoms evaluasies uit te voer nie. ‘n Tipologie is opgestel deur verskillende insette, uitsette en uitkomstes van UTIID- projekte te identifiseer. Die “component-function” is toegepas op 16 UTIID- projekte en daar is gevind dat dit wel ‘n effektiewe metode is om die sisteem te evalueer, swakhede te identifiseer en gereedskap voor te stel om die swakhede aan te spreek.

Laastens, is ‘n raamwerk vir die evaluasie van UTIID- projekte voorgestel deur die tipologieë en “component-function” metode saam te smelt. Die raamwerk beoog die daarstelling van geskikte evalueringsgereedskap om UTIID- projekte op ‘n sisteemvlak te evalueer en hul uitkomstes te klassifiseer.

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LIST OF ACRONYMS AND ABBREVIATIONS

AHP	Analytical Hierarchy Process
BOP	Base of the Pyramid
CFA	Conceptual Framework Analysis
CPUT	Cape Peninsula University of Technology
DEA	Data Envelopment Analysis
DST	Department of Science and Technology
GT	Grounded Theory
ICT	Information and Communication Technology
IIS	Inclusive Innovation System
IS	Innovation System
NGO	Non-Governmental Organisation
NRF	National Research Foundation
SA	South Africa
SD	System Dynamics
UCT	University of Cape Town
US	University of Stellenbosch
UTIID	University-driven Technology-based Innovation for Inclusive Development
UWC	University of Western Cape

CHAPTER 1 INTRODUCTION

1.1 Innovation for inclusive development and the role of universities.

Hammond & Prahalad [1] defined the four billion poorest people who earn between $1 or $2 per day as the 'base of the pyramid' (BoP) population. Alleviating poverty is a challenge that various organisations and institutions continuously try to address. Innovation is seen as a key driver of economic growth — it induces the development of products and services for consumers and increases industrial economic development. Although economic growth has played a vital role in decreasing absolute poverty, there are growing concerns that innovation has also contributed to inequality and exclusion. Although a thriving body of knowledge is developing, the economic periphery such as informal microenterprises, affordable goods and services, and innovation to solve wider social challenges, has traditionally been neglected in innovation policy thinking and practice [2].

Several authors have stated that alternative or non-traditional innovation models could be used to stimulate economic inclusion and growth for those in the BoP [2],[3]. The literature highlights two main types of innovation models that can be applied towards these goals. The first type are models where products and services are specifically developed for the benefit of lower income markets. Here the BoP is viewed as a potential customer, and the goal is mainly to decrease costs and produce more affordable products and services. These innovation modes are often referred to as 'appropriate technology' [4], 'frugal innovation', 'pro-poor innovation', and 'BoP innovation' [5]. The second type of innovation model takes a more developmental approach. Examples of this type include 'inclusive innovation', 'innovation for inclusive growth' [6], and 'innovation for inclusive development' [7]. These are terms used to describe innovations that "create or enhance opportunities to improve the wellbeing of those at the BoP" [6]. Here the aim is that BoP individuals be regarded not only as potential customers but also as business partners who are included in the innovation process, so that, as solutions are conceptualised and developed and goods are manufactured, they can benefit economically from such innovations.

Literature looking at the role of universities in innovation for inclusive development have considered factors such as the drivers and forms of university-community interactions, the role and nature of partnerships, the role of interactive learning platforms, the degree of community involvement, enablers and constraints, knowledge flows and skill development as well as infrastructures and process required to monitor outcomes [8]–[11].

The definition for innovation for inclusive development used in this study is the *"Improvement of living conditions and creation of employment opportunities for the poor through the development of new products, services, processes and business models aimed at resource poor communities"*[12].

1.2 The developmental university

Up to the late 1990's, community engagement was not a priority function for South African universities [13]. In 1997, the White Paper on Transformation of Higher Education highlighted that the higher education system and institutions were required to make community engagement a primary goal in order to address national needs [14]. It calls on universities to conduct research, provide expert knowledge and the required infrastructure to equip society with the capacity to meet societal challenges.

Following this White Paper, the Department of Science and Technology (DST) set out to encourage university-industry interaction in order to address societal needs in SA. The DST established new platforms and incentivised funding platforms to achieve this. From 2005 the Higher Education Quality Council requisitioned institutional audits which stimulated increased commitment to 'community engagement'. In 2008, new legislation was introduced to promote the use of intellectual property (IP) for social and economic development. The Technology and Innovation Agency was established to induce this utilisation of knowledge and technological innovation and the development of technology transfer offices at all universities [15].

Over the years the role of universities has evolved to include social and economic development in addition to the traditional roles of teaching and research [16]. Dimensions of the university-driven community engagement can take several forms including "community-based research", "participatory action research", "distance education", "professional community service" and "service-learning" [13].

1.3 Background of the study

In 2014-2015, a small-scale research pilot project was launched to investigate innovation for inclusive development in South Africa (SA), specifically in universities. This project was launched by the Centre for Frugal Innovation in Africa, which is an inter-university research program run by Leiden University, Delft University of Technology and Erasmus University Rotterdam. The main objectives of this study was to determine the roles of South African universities in innovation networks, specifically looking at universities as hubs of knowledge/ skill creation and dissemination.

The pilot project entailed an exploratory empirical study on innovation for inclusive development projects at four universities in the Western Cape region of SA, namely the University of Cape Town (UCT), University of Stellenbosch (US), University of the Western Cape (UWC) and finally Cape Peninsula University of Technology (CPUT). The aim of the study was explore if and how universities in SA are engaged in innovation for inclusive development activities, and if so how are they performed, by whom are they performed and what were the results of such activities.

The pilot study focused specifically on University-driven projects that developed/used technology focused innovations to bring about inclusive development. These projects will from now on be referred to as University-driven Technology-based Innovation for Inclusive Development (UTIID) projects. The pilot study

identified and analysed 15 UTIID projects and performed interviews with the project leaders of each projects in order to gain a broad understanding of these UTIID projects. The study identified the 'types of innovation', the 'degree of new technical knowledge', the 'level of inclusiveness', the 'innovation pathway' and the 'embeddedness' of the project within an innovation platform.

From the results of the pilot study, the research team constructed an analytical framework and research agenda to help future researchers generally understand and survey UTIID projects. The analytical framework was constructed using the 'components of innovation systems' approach. The results and analytical framework of the pilot study are to be published later in 2016. Table 1 below shows a summary of the analytical framework developed by the pilot study research team (Grobbelaar *et al* [17]*)*.

Table 1: UTIID research agenda proposed by Grobbelaar *et al* [18]

Component	***Important themes identified from pilot study***
Innovation	The type and nature of innovation, drivers of innovation process, strategies and innovation processes.
Actors	The characteristics of contributors, the various actors involved in the innovation process as well as the role that each fulfils, and; actor abilities.
Relations	Interaction between actors, specifically focused on partnerships; the degree of and mechanisms used for community engagement; the capabilities of partnerships to become sustainable and to form learning platforms, and; the enabling roles of partnerships.
Infrastructure (Knowledge, Physical and Financial)	Knowledge, financial and physical infrastructure; the management of these infrastructures and innovation platforms.
Institutions	The management of intellectual property; fostering trust; collaborative approaches to development of knowledge, and; mechanisms for arranging UTIID projects and community involvement.

In conclusion of the pilot study, Grobbelaar *et al.* [17] state that further research is required in order to start assessing the external socio-economic impacts of UTIID projects. This thesis forms part of the follow up study that focusses specifically on the monitoring and evaluation of UTIID projects and their outcomes. The following section will describe the problem to be addressed in more detail.

1.4 Problem statement

Citing several authors [19], [20], Kruss [21] highlights the current debate regarding the relationship (its boundaries, required forms of knowledge and actor definitions) between universities and society in SA. Literature suggests that there exists conceptual confusion in this field.

Hall [20] argues that further research has to be conducted to conceptualise 'community engagement' in a space that is separate from the state and the market, called the 'third space'. He suggested that in order to do this studies need to be conducted to determine what universities are actually doing in terms of research, teaching and community engagement, as well as the institutional infrastructures available to induce responsiveness and new institutions that form to meet developmental needs. This notion is supported by Muller and Subotzky [22] who suggested that the way forward is to examine what is being done in order to develop a typology of successful engagement practice.

Collaboration during innovation projects, and more specifically technological innovation projects, results in the co-production of knowledge and increased capabilities which may address both economic and societal challenges. The importance of academic engagement to impact local societies is increasingly being emphasised in literature [23]. Case studies conducted by Kruss *et al*. [24] predict that increased university-community engagement could enhance the impact of SA universities on local societal and economic development.

Grobbelaar *et al.* [17] suggest that it would be of great value if one could measure and evaluate the outcomes of such university-driven projects. They continue to state that this is however a daunting task and that there exists a gap in literature concerning the nature and extent of such outcomes.

In order to evaluate UTIID projects and their outcomes, an evaluation tool is required. Such an evaluation tool requires a systems approach to evaluation. The evaluation tool would involve the identification of the components of a project, the identification of inputs and outputs, and finally an analysis of the system functions within the project. This combined component-function approach to the evaluation of UTIID projects would enable us to open the ‘black box’ of innovation and look at the inclusion and outcomes within the innovation process.

1.5 Research objectives

The aim of this study is to develop an evaluation framework and tool that can guide the evaluation of UTIID projects. In order to develop such an evaluation tool, the following objectives must be realised:

1. Conduct a systematic literature review to identify an appropriate methodology that can be adapted for the evaluation of UTIID projects.
2. Evaluate monitoring and evaluation practices in current UTIID projects through in-depth case studies.
3. Construct Input, Output and Outcome typologies based on the UTIID project case studies that can be used for diagnosis and technical advice in future UTIID projects.
4. Validate the component-function approach (identified in Objective 1) as an applicable approach for the evaluation of UTIID projects by applying it to case studies.
5. Synthesise the findings from Objective 2 to 4 to propose a comprehensive tool that can be used to evaluate UTIID projects and classify their outcomes.

1.6 Research scope and limitations

As is the case of any study, this study has limitations. The predefined systematic literature review methodology is advantageous as it reduces bias in the review process, but it also has advantages. The structured systematic review only provides answers to specific questions [25], [26]. The review only included studies that are written in English, which excluded several studies. The search was also restricted to studies that specifically refer to the search terms. While this approach is consistent with the goal of identifying a suitable method/approach, it also excluded several research streams that attempt the evaluation of Inclusive Innovation Systems (IIS).

Data is collected by performing interviews with the project leaders (project champions) as they are the drivers of the projects. This is however a limitation in this study, as it could be of value to gain insights on the perspectives of other actors that participate in these projects, such as the marginalised community members. There are various actors involved in these projects and this study will be limited to the data collected from a single actor, the project leader. This is acceptable for this study as the project leaders are the drivers of the projects with most knowledge on the various aspects of the projects.

The UTIID project evaluation tool will be developed from assembling an analytical framework described in literature with deductive findings from interview transcripts. The application of the final evaluation tool falls outside of the scope of this study.

1.7 Document outline

Table 2 describes the outline of this thesis. The chapters follow in a logical order based on the Conceptual Framework Analysis approach, which will be explained in more detail in Chapter 2. The chapters in this thesis are structured as follows:

Table 2: Document outline

Chapter 1: Introduction
This chapter provides background on the study and identifies the problem statement. It then lists the research questions that we aim to answer and the objectives that need to be achieved in order to do so.
Chapter 2: Methodology
Chapter 2 entails a presentation of the study's research design. The chapter also includes a description of the Grounded Theory methodology and lists the advantages of its use to solve the problem at hand.
Chapter 3: Inclusive innovation systems
Chapter 3 provides a short literature review on innovation systems and introduces the inclusive innovation system as a lens through which to analyse UTIID projects.
Chapter 4: Systematic literature review on the evaluation of inclusive innovation systems
In this chapter a systematic literature review is performed in order to identify an innovation system evaluation approach that would be applicable to the evaluation of UTIID projects. 106 studies are

reviewed and the innovation system component-function approach is identified as an appropriate approach.
Chapter 5: Analytical framework: Component-function approach
This chapter provides a literature review of the component-function approach.
Chapter 6: Case studies
16 UTIID projects are identified as case studies and interviews are conducted with project leaders in order to execute the following steps: 1. Investigate the current state of monitoring and evaluation in UTIID project 2. Construct typologies of the inputs, outputs and outcomes of the UTIID projects based on the projects in our sample. 3. Apply the analytical framework (component-function approach) described in Chapter 5 to 16 case studies in order to validate the approach as an appropriate approach for the evaluation of UTIID projects.
Chapter 7: Conclusions Part 1: Evaluation tool development
In this chapter the theoretical framework developed in Chapter 5 is merged with the typology developed in Chapter 6 to construct an evaluation tool that can be used to evaluate UTIID projects.
Chapter 8: Conclusions Part 2
The final chapter concludes the study with a concise summary of the research conducted and the findings of the study. The limitations of this study as well as recommendations for future work is discussed.

1.8 Chapter summary

To summarise, Chapter 1 provides an introduction to this study by first discussing the background of the study. Here the pilot project conducted by Grobbelaar *et al*. [18] and its results are discussed. The pilot study set the foundations for this study. The problem to be addressed is that of a gap in literature regarding approaches to evaluate UTIID projects and their outcomes. The research questions and objectives defined to address this problem are listed and finally the chapter concludes with a description of the layout of this thesis.

In the next chapter, the research design and methodologies followed within this study will be described.

CHAPTER 2 METHODS

Chapter 2 provides an overview of the methodology used in this thesis to develop a tool to evaluate UTIID projects. The chapter starts with a short literature review on grounded theory and the Conceptual Framework Analysis (CFA) approach [27]. This is followed by a description of how the CFA approach was adapted for the purposes of this research.

Chapter 2 provides an overview of the following:

- The methodology used in this study: Grounded Theory.
- A breakdown of the steps performed in order to develop a tool to evaluate UTIID projects. .

2.1 The Grounded Theory Methodology

Grounded theory (GT) is a research methodology that involves the use of coded paradigms in a systematic approach aimed to obtain data and discovery of theory. Grounded theory is used when a researcher attempts to produce a theory that is closely related to the context of the subject under study [28]. A grounded theory should consist of explanations and descriptions.

Similar to other qualitative approaches, various sources can be consulted in order to gather data for grounded theory. The data collection procedure entails consulting sources such as books, letters, documents and conducting interviews or observations and then coding them all in the same way [29]. There are specific procedures to follow in data collection for grounded theory, but there is some flexibility within these specifications. The qualitative GT method proposed by Jabareen [27] called 'Conceptual Framework Analysis' (CFA) was used as an overarching methodology in this thesis.

2.1.1 ARGUMENTS FOR USING THE CONCEPTUAL FRAMEWORK ANALYSIS METHOD

The literature lists several arguments for using the CFA, which is a GT method, and these are listed below:

- It is an inductive methodology [27].
- It is a widely used methodology, especially in social sciences [34].
- The method is contextual [34].
- The method provides a process-oriented account and explanation of the phenomenon [36].
- The method fosters creativity [30].
- It is a systematic approach towards data analysis [30].
- It ensures richness and depth of data [30].

In summary, the main advantages of the CFA method are that it provides structured guidelines that helps researchers conduct qualitative research and gather rich data. It is an intuitive approach which is especially

helpful in conceptualizing new theories in areas that are not well researched, and therefore it suits this study well, as the literature on IIS evaluation is still very limited.

2.1.2 DESCRIPTION OF CONCEPTUAL FRAMEWORK ANALYSIS METHOD

A conceptual framework is defined as "a network or a 'plane,' of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena" [27]. The CFA method focuses on the process of constructing a conceptual framework for complex social and multidisciplinary phenomena that is linked to various bodies of knowledge. The CFA method requires the following: (1) The data should be collected from multidisciplinary literature and come from various types of sources; and (2) The development process should be iterative and comparisons need to be made between the data gathered. This method is comprised of seven different steps which was used as a guide this study, namely:

Step 1: Map the selected data sources: This step entails the extensive review of multidisciplinary literature regarding the specific phenomena.

Step 2: Extensive reading and categorizing of the selected data: This step entails the reading of the identified literature and categorisation, both according to discipline and importance.

Step 3: Identifying and naming concepts: In this step, the analyst is meant to discover concepts from the literature and 'code' them.

Step 4: Deconstructing and categorising: Here, each concept is deconstructed into its main characteristics.

Step 5: Integrating concepts: This step aims to group similar concepts into one new concept.

Step 6: Synthesis and re-synthesis: This step entails the iterative process of synthesizing concepts into an analytical framework.

Step 7: Validating the conceptual framework: This step sets out to validate the framework.

2.2 Research design

Figure 1 below provides an overview of the methodology followed in this thesis, and it specifically shows how the different steps of CFA were utilised to develop an evaluation tool.

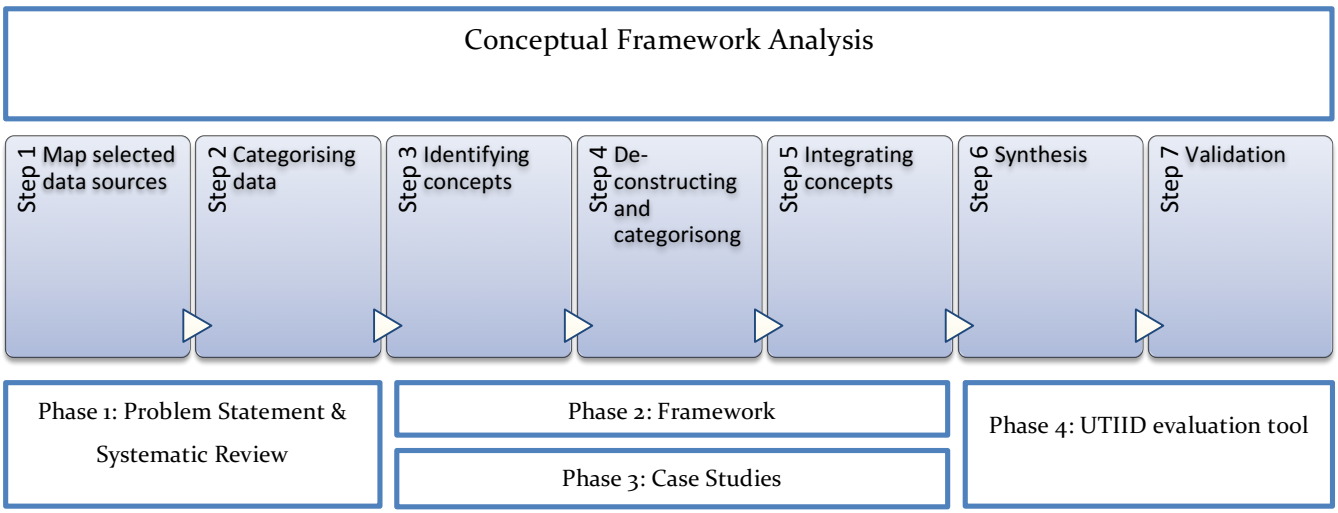


Figure 1: Overview of research methodology

validating an evaluation tool as shown in Figure 1, can be further described as follows:

2.2.1 PHASE 1: PROBLEM STATEMENT & SYSTEMATIC REVIEW

Phase 1 comprises the following steps of the CFA methodology:

- The problem is identified and research questions are constructed (Chapter 1 and 3) then the data sources are identified (Chapter 4).
- Literature on IIS evaluation is categorised and analysed and an appropriate evaluation approach is identified (Chapter 4).

These two steps are discussed in more detail below:

Before commencing data collection, it is important to first clearly define the problem and to identify the primary objectives of the analysis. This thesis states the problem in Chapter 1. The literature study in Chapter 3 provides further insight into and background on the problem.

Problem Statement
Chapter 1: Introduction and Background
• Background to this study • Problem Statement • Research Questions
Chapter 3: Inclusive innovation systems
• Innovation system approach

• Inclusive innovation system approach

In Chapter 4, a systematic literature review is conducted in order to identify an appropriate approach for the evaluation of IIS.

Systematic Literature Review
Chapter 4: Systematic Literature Review on the Evaluation of IIS
• Data collection • Data selection • Data analysis • Selection of approach to evaluate IIS

This section provides a description of the methodology followed to perform the systematic literature review. As described in the introduction, the aim of this review is to identify an approach that will be applicable to the evaluation of IIS. The research questions that we therefore set out to answer with this review are:

1. Which methods or approaches are applied to the evaluation of IS and IIS in literature?
2. Which of these methods or approaches would be most suitable for the evaluation of IIS?

The review process followed a three phase process described by Maldonado and Grobbelaar [31]. The three phases shown in Figure 2 are (1) Data collection, (2) Data selection, and (3) Data analysis.

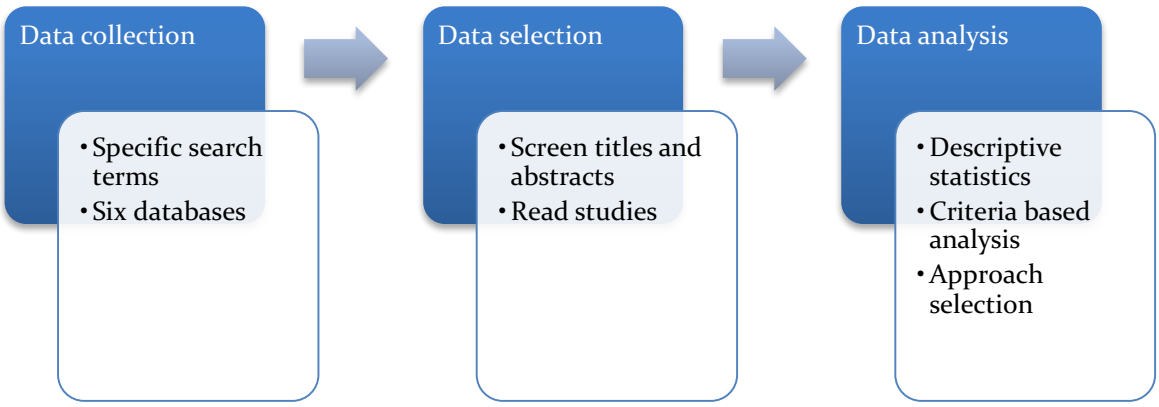


Figure 2: Systematic review methodology

Literature on the evaluation of IIS is still in its infancy, we therefore decided to broaden our search to look at methods or approaches used to evaluate traditional IS as well. This section will describe the steps followed to collect data as well as the selection criteria used.

Step 1: Data collection

Methodology

Existing literature was identified using six data bases namely, Scopus, Web of Science, Academic Search Premier, Emerald, Science Direct and ProQuest. The search terms used are shown in Table 3. Both peer-reviewed and grey literature studies were included. Studies were only considered if written in English.

Table 3: Search terms

Group	***Terms***			***Information***
Methodology	Approach*	Method*		Title, Abstract, Keywords.
Innovation Systems	Innovation System*	System of Innovation*	Inclusive Innovation System*	Title, Abstract, Keywords.
Purpose	Evaluation*	Analys*		Title

Step2: Data Selection

Studies were identified using the pre-defined search terms. A list was constructed with all papers initially included. The data selection started with a review of the title and abstract of each paper. Papers were discarded if they were not related to the evaluation of IS/IIS.

Step 3: Data Analysis

The second stage of analysis entailed the review of each study in order to code them and identify methods used.

In order to identify an appropriate method for the evaluation of IIS, the third stage of analysis entailed the assessment of each approach in order to compare and draw insights from different methodologies, and ultimately select the most suitable approach.

Two sets of criterion were constructed according to which each method could be assessed [32]. The first set was used to determine the method's functionality as an evaluation approach. The first set of criterion is primarily based on the criteria defined by Schut *et al.* [33]. These criteria are listed below:

1. Mixed data: An evaluation approach should produce both qualitative and quantitative data. Qualitative data provides the means to identify various dimensions of complex problems within an IS. It also provides insights on structures that inhibit or induce innovative capacity. Quantitative data Quantitative data provides descriptive and statistical data that complements qualitative data [33].
2. Internal and external analysis: Analysis should be conducted by both internal stakeholders and independent external researchers [34].
3. Analyse various cross-level actors: The approach should be applicable to various actors at different levels [33].
4. Integrated analysis: An evaluation approach should encompass an integrated analysis of system functioning, complex problems and innovative capacity [35].

5. Identify system failures: Identify system dysfunctions by identifying system failures [36].

The second criteria assessed the applicability of the use of the methodology to evaluate IIS specifically. In other words, it specifies the requirements an approach should meet in order to be suitable for the evaluation of IIS.

These criteria are listed below:

1. Actor-oriented: The method must identify both the demand- and supply-side actors that are present within an inclusive innovation system [37].
2. Focus on the complex relations between the actors i.e. the method/approach must be able to identify the "informal, loose but socialised relations" that are present in IIS [38]. It must focus on how these relationships foster learning and capability transfer, diffusion and retention to the BoP [37], [39].
3. The method/approach must be able to take the context of the system into consideration – it therefore must be used in such a way that rich qualitative data is gathered and retained [40].
4. The method/approach must also be able to analyse the processes within the system [41], [42].

After each of the approaches are evaluated using the above mentioned sets of criteria, the most appropriate approach can be selected.

2.2.2 PHASE 2: ANALYTICAL FRAMEWORK

Based on the results of the systematic literature review in Chapter 4, the IS Component-Function approach is identified as the most appropriate approach for the evaluation of IIS. Chapter 5 then provides a literature overview of this approach and proposes an analytical evaluation framework.

Literature Review
Chapter 5: Analytical framework: Component-function approach
• Components of IIS • Functions of IIS • Functional analysis • Systemic problems • Systemic instruments

2.2.3 PHASE 3: APPLICATION OF FRAMEWORK TO CASE STUDIES

Phase 3 comprises the following steps of the CFA methodology:

- A literature study is conducted on the IS Component-Function approach in order to construct an analytical evaluation framework (Chapter 5). After this is completed, Phase 3 commences, where this framework is applied to 16 case studies (Chapter 6) in order to identify areas of the framework that must be adjusted to suit the UTIID project context.
- New concepts regarding the characteristics of UTIID projects and the evaluation of UTIID projects are then identified and;
- Synthesised into the analytical framework, causing some adjustments to the original structure (Chapter 6).

Case study research
Chapter 6: Case studies
• Collect case study data: Interviews • Overview of monitoring and evaluation in current UTIID projects • Map inputs, outputs and outcomes of UTIID projects • Perform component-function analysis

In order to perform Phase 3, case studies were selected and interviewed in order to collect all the necessary data. The case study methodology is described below.

2.2.3.1 CASE STUDY METHODOLOGY

This section will describe the data collection methodology. It starts with an overview of the case study methodology followed. Next it described the study design and finally the process of identifying UTIID projects to form part of our sample.

A pilot study (completed in Western Cape, South Africa in 2014) by Tijssen & Dijksterhuis [23] on university contributions to innovation for inclusive development projects provided an outline of the typical activities and outputs within a range of UTIID projects. The research design entailed a survey of a set of UTIID projects selected from four different universities in the Western Cape. This survey identified attributes of UTIID projects including the 'types of innovation', 'level of inclusiveness', 'inclusive innovation pathways', the 'institutional embeddedness' and the types of 'impact' of these projects. From the results of this pilot study Tijssen et al. [17] constructed a UTIID research agenda framework for understanding UTIID projects in general. This framework adopts the 'innovation system components' approach and provides a varied list of research themes for future studies. This study provided a sense of patterns in the 'innovation system components' of UTIID projects. The research agenda framework constructed by Tijssen et al. [17] had a direct effect on the framing of this research study.

The emphasis of this new empirical study is on the measurement, and evaluation of socio-economic impacts brought about through UTIID projects. Analysis of interactions and socio-economic impact of UTIID projects was guided by a selection from Tijssen et al. [17] conceptual classifications and key definitions. The research questions are thus:

1. To what extent, how and by whom have the socio-economic impacts of UTIID projects been monitored or evaluated?

2. What are the metrics and measures used to monitor or evaluate the socio-economic impacts of UTIID projects?

2.2.3.2 STUDY DESIGN AND SURVEY METHODOLOGY

An exploratory study was conducted, thus open-ended methods were used that enabled the collection of rich qualitative data [40]. The same interview and analysis methodology was used in order to compare and draw insights from the different projects. The patterns recognised and insights gained serve as a basis from which to contribute to the gap in literature regarding the evaluation of impact of UTIID projects.

The survey design depended on identifying existing university projects that use technology focused innovation to benefit marginalised communities. The goal was to identify and include as many projects that meet the pre-defined criteria. It was found that such projects are quite scarce in South African universities and it is important to note that this study is not statistically significant within the total collection of university programmes.

The study design consisted of semi-structured interviews with UTIID staff members, preferably the project leader or champion. A pre-interview questionnaire was e-mailed to be to the interviewee to be completed before-hand. This was done to gain sufficient background on each project before the interviews. This was followed by a face-to-face interview of maximum one hour. The interview questionnaires were constructed around the component-function-based approach and a series of topics to identify outputs and outcomes. Some of the research questions were adapted from the pilot study [23]. The interviews were recorded and then transcribed afterward. The interview methodology was approved by the Stellenbosch Research and Ethics Committee and each interviewee signed a written consent form as it was prerequisite to ethical clearance. The interviews were supplemented by the analysis of documents collected from the interviewees such as presentations, reports, thesis's and publications about the UTIID projects.

2.2.3.3 IDENTIFYING UTIID PROJECTS

The selection of UTIID projects was confined to four universities in the Western Cape namely, the *University of Cape Town* (UCT); *Stellenbosch University* (SU); *Cape Peninsula University of Technology* (CPUT); and the *University of the Western Cape* (UWC).

An extensive web search was conducted to identify potential UTIID projects. Information about each project was analysed against a selection criterion. The criteria is largely based on the criteria defined Grobbelaar *et al*.

[18] with one addition – as this study is specifically focused on impact evaluation, we added another criterion which stipulates that the innovation must be implemented. We defined 'implemented' as at least tested in a 'real life' setting. Thus the selection criteria are:

- The project aims to improve the living standards (social and economic) of the members of marginalised community;
- The project must be university-driven i.e. one or more university representatives play a significant role in the project (these can be students, faculty members or administrators);
- The innovation must be technology-based i.e. technology is a central component of the innovation, and;
- The innovation must be implemented.

2.2.3.4 COMPONENT-FUNCTION ANALYSIS

The methodology used to conduct the component-function approach was designed by Wieczorek and Hekkert [43]. It is made up of five stages shown in Figure 3. The approach entails the identification of components in order to assess the actors, relations, infrastructure and institutions present in each project. This is followed by a descriptive functional assessment during which systemic problems are identified and systemic instruments are designed to address these problems.

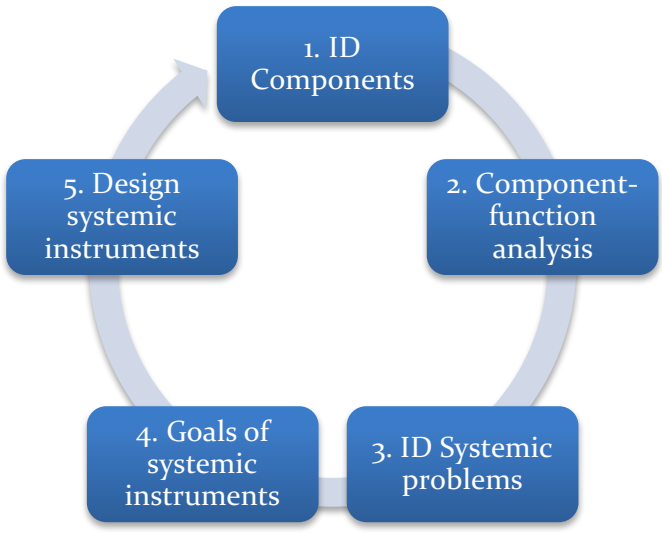


Figure 3: Framework for the analysis of innovation systems [141]

2.2.4 PHASE 4: EVALUATION TOOL DEVELOPMENT

Phase 4 comprises the following steps of the CFA methodology:

- The analytical framework described in Chapter 5 is adjusted based on the findings of the case studies performed in Chapter 6. General findings from the case studies an input, output and outcome typology

are also synthesised with the theoretical framework in order to develop and evaluation tool (Chapter 7).

The development of the evaluation tool
Chapter 7: The Development of the Evaluation Tool
• Developing a typology • Component-Function Analysis • Assembling the evaluation tool • The UTIID evaluation tool

2.3 Chapter Summary

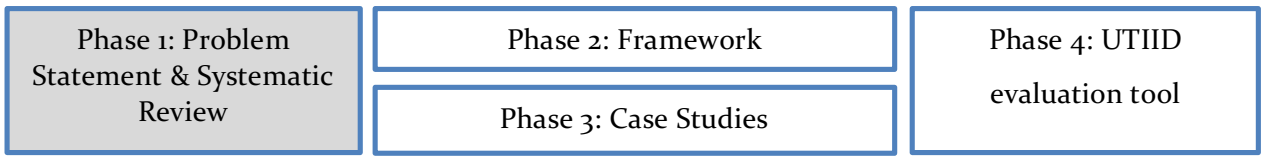
This chapter provided a short overview of the GT approach and advantages of using it. This was followed by a description of how the steps of the CFA method were used to execute the four different phases of this study namely, Phase 1: Problem Statement and Systematic Review; Phase 2: Theoretical Framework; Phase 3: Case Studies; Phase 4: Evaluation Tool. Table 4 summarises the overarching methodology used in this study and shows the specific chapters in which each phase was applied.

Table 4: Methodology according to chapters of this document

Phase 1: Problem Statement and Literature Review
Chapter 1: Introduction and Background
• Background to this study • Problem Statement • Research Questions
Chapter 3: Inclusive innovation systems
• Innovation system approach • Inclusive innovation system approach
Chapter 4: Systematic Literature Review on the Evaluation of IIS
• Data collection • Data selection • Data analysis • Selection of approach to evaluate IIS
Phase 2: Literature review on component-function approach

Chapter 5: Analytical framework: Component-function approach
• Components of IIS • Functions of IIS • Functional analysis • Systemic problems • Systemic instruments
Phase 3: Case study research
Chapter 6: Case studies
• Collect case study data: Interviews • Overview of monitoring and evaluation in current UTIID projects • Map inputs, outputs and outcomes of UTIID projects • Perform component-function analysis
Phase 4: The development of the evaluation tool
Chapter 7: The Development of the Evaluation Tool
• Developing a typology • Component-Function Analysis • Assembling the evaluation tool • The UTIID evaluation tool

CHAPTER 3 INCLUSIVE INNOVATION SYSTEMS



Chapter 3 provides a brief literature review on the innovation system (IS) framework and the inclusive innovation system framework, highlighting the differences between the two.

Chapter 3 intends to achieve the following:

- Describe the innovation system framework.
- Describe the inclusive innovation system framework, its components and functions.

3.1 Innovation system perspective

According to Biggs & Underwood [44] there exists a need to move beyond the program/project level of monitoring and evaluation. They argue that a more holistic approach is required, as the linear (predominantly black-box) evaluations do not provide insights concerning ways to improve the whole innovation process. The Innovation System approach is suggested as a lens through which to approach evaluations. This will shift the evaluation focus from a problem solving framework to a learning framework [44]. By using this IS perspective we propose that we can open the 'black-box' of innovation at look at the outcomes of the whole innovation process.

Figure 4 below shows a process map of innovation for inclusive development with all the different phases of the innovation process. For the purpose of this paper, the authors use the term 'innovation for inclusive development'.

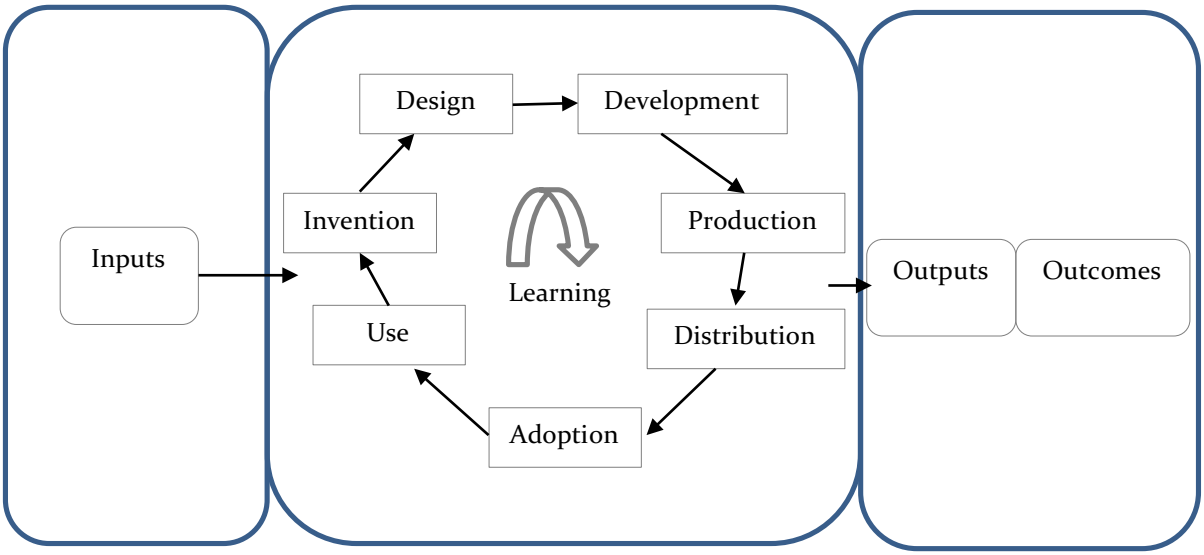


Figure 4: Process map of innovation for inclusive development [69]

Based on these recommendations from literature, we will now proceed to adopt an innovation systems perspective to the analysis of UTIID projects. The following section will describe the components and functions of the IS framework as well as the differences between the traditional IS and IIS.

3.2 The innovation systems framework

Models of innovation have been evolving and five generations of innovation models could be identified from literature [45]. The first and second generation models are linear models of innovation, driven by demand pull and technology push. The linear view is however very simplistic and has many problems such as the lack of feedback paths and "feedbacks and trials are essential" [46]. The third generation introduced the "chain-linked model" which acknowledged feedback loops. The fourth generation innovation models are parallel line models which entails integration within the firm with its supply chain and customers. This innovation model emphasises the linkages and relationships between these components. Fifth generation innovation models consists of systems integration and extensive networking models of innovations that allow for flexible response and continuous innovation [45].

The development and implementation of innovations are not isolated, but occur within a socio-cultural context [47]. Freeman [48] defined innovation systems as "networks of institutions, public or private, whose activities and interactions initiate, import, modify and diffuse new technologies". The Innovation Systems (IS) framework is used to define how actors and institutions work in partnership to exchange knowledge to develop, produce and diffuse innovations.

Citing several authors such as Freeman [48], Edquist [49] and Nelson [50], Foster & Heeks [38] listed the following as the five core structural components of an innovation system:

1. Innovation;
2. Actors and Networks;
3. Knowledge and Learning;
4. Relations;
5. Institutions.

Innovation in traditional ISs is supply-side driven and growth-orientated [38]. Actors are the components that are involved in innovation activities. These may include, but are not limited to firms, universities and research institutes, institutions and organizations. The IS framework distinguishes between institutions and organizations. Institutions refer to formal institutions such as laws, regulations and standards as well as informal institutions such as cultural facets, traditions, norms and codes of conduct etc. Institutions influence the behaviour of individuals and organisations. In contrast, organisations are entities made up of individuals with shared objectives. Organisations are governed by formal and informal institutions as well as internal rules [51].

Carlsson & Stankiewicz [52] defines the Technology Innovation System (TIS) framework as "a network of agents interacting in the economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology". TIS literature continued by introducing the concept of system functions. System functions can be defined as all activities that contribute to the development and diffusion of innovations and support structural components in an innovation system [53]. A full set of functions have not yet been agreed on in literature. Hekkert et al. [53] and Bergek et al. [41] have however defined a very comprehensive list of functions which can be viewed in Table 5 below.

Table 5: Functions of IS [41], [53]

Function	***Description of Function***
F1: Entrepreneurial activities	Functions through which the potential of new knowledge, networks and markets" are exploited into tangible actions, taking advantage of possible business opportunities.
F2: Knowledge development	This function encompasses all activities related to the processes of knowledge development and learning. Incudes 'learning by searching' and 'learning by doing'.
F3: Knowledge exchange	This function encompasses all activities responsible for the facilitation of interaction within and between networks. The focus of this function is knowledge transfer and diffusion and the accessibility of knowledge and resources.

F4: Guidance of search	This function provides guidance on the specific foci to be chosen for further investment.
F5: Market formation	Functions through which a market is formed for new technology.
F6: Resource mobilisation	This function encompasses all activities that provide support to access Human and Financial resources.
F7: Creation of legitimacy	This function encompasses all activities that support the increased acceptance of a technology.

3.3 Inclusive innovation systems

Kuhlmann and Rip [54] suggests that there is evidence of a new regime that goes beyond the traditional technology-push model – "collective experimentation" that occurs in response to pull factors such as society's greatest challenges. They suggest that the development of inclusive innovation systems is "grand societal experiment" that requires:

- A new constellation of actors and interactions that result in a greater variety in options;
- A new range of institutions;
- Social innovation;
- New capabilities;
- New ways of actor engagement.

Foster & Heeks [38] set out to determine whether the IS framework is applicable to inclusive innovation, and whether/how it should be modified to be applicable. They analysed IS through the five core components: innovation, actors, learning, relations and institutions. And compared it to what is already known to inclusive innovation. Results show that it is entirely appropriate to use a systems of innovation framework to analyse inclusive innovation: as it consists of a system of actors who have relations, learn, develop and innovate within an institutional environment. The focus of each component is however slightly adjusted in inclusive innovation systems. Inclusive innovation systems are made up of interconnected components that work together to develop and diffuse innovations aimed at resource-poor individuals or groups in order to present a positive contribution to improved life conditions and upward mobility [55],[56]. Table 6 below summarises the differences between components in IS and IIS.

Table 6: Comparison between components of IS and IIS [6]

Components	***Innovation system framework***	***Inclusive innovation system***
Actors	Focus on: Supply side identifiably organisations that are large, located and formal. Intermediaries: R&D brokers	Greater emphasis on non-traditional, demand-side innovators, low income consumers. Intermediaries: Innovators that apply adaptive and incremental innovation to compensate for the frequent mismatch between externally innovations and internal needs.
Innovation	Supply-side driven, growth-orientated.	Incremental innovation, demand-driven and aimed at meeting local needs.
Learning	Innovation emerges through learning: learning-by-doing, learning-by-using, learning-by-interacting.	This type of learning is key to serving excluded markets. Learning about use and diffusion, learning about wider social processes.
Relations	Formal	Informal, close and loose, flexible relations
Institutions	Emphasis is on formality: formal rules and regulations that guide actions of IS actors.	Requires the recognition that formal regulations may be present in theory but not in practice. Inclusive innovation also recognises informal institutions: understood as the behavioural norms Embedded within local social relations that are endogenou sly enforced rather than exogenously imposed

3.4 Chapter summary

This chapter introduced the innovation system perspective to evaluation of UTIID projects. A brief overview of traditional innovation systems framework was described and then the inclusive innovation system framework was introduced. Finally, the differences between the two frameworks are shown and as confirmed by the literature review conducted by Foster & Heeks [38], the IS component-based approach can be used to provide insights into the actors, types of learning, relations, infrastructure and institutions of IIS's, but it requires a content modification due to the fact that structural components of an IIS differ from that of a traditional IS.

CHAPTER 4 SYSTEMATIC LITERATURE REVIEW ON THE EVALUATION OF INCLUSIVE INNOVATION SYSTEMS

Phase 1: Problem Statement & Systematic Review	Phase 2: Framework Phase 3: Case Studies	Phase 4: UTIID evaluation tool

In this chapter we conducted a systematic literature review in order to identify the most applicable approach to evaluate IIS.

Chapter 4 intends to achieve the following:

- Conduct a systematic literature review to identify evaluation methodologies used in literature to evaluate innovation systems.
- Use the pre-defined criteria to assess each evaluation methodology and select one that will be most appropriate for the evaluation of UTIID projects.

4.1 Introduction

Several authors have stated that the use of the Innovation Systems (IS) and Inclusive Innovation Systems (IIS) approaches can provide a more complete understanding of a processes and have emphasised its possible applicability to the analysis of innovation in marginalised communities [33],[57]. The IS approach is characterised with a move from a problem solving framework towards a framework that induces 'learning' [44]. Based on these recommendations from literature the IS and IIS approaches were selected as a lens through which to assess University-driven, Technology-based, Innovation for Inclusive Development (UTIID) projects.

An initial review of IIS literature revealed that there is a gap in the literature regarding methods to evaluate IIS. Traditional linear evaluation methodologies are unable to provide new insights regarding ways to improve the process of innovation [33]. The literature remains wanting in terms of primary data [38], and tools and methodologies to evaluate IIS. Heeks *et al*. [37] suggest that an IIS has to be assessed with a process-level approach that can open the 'black-box' of innovation, enabling the evaluation of inclusion in the whole innovation process.

4.2 Reasons for Performing a Systematic Literature Review

Systematic literature reviews are a method for gaining understanding of a vast body of information. It enables a researcher to differentiate between real and assumed knowledge. Literature highlights three most common reasons for conducting a systematic literature review [25]:

1. To summarise existing evidence relevant to a certain topic area or research question.
2. It is a method of identifying areas where insufficient research has been done and where gaps in the literature exist in order to suggest areas for further investigation.
3. To gain understanding or provide a framework in order to position new research activities.

4.2.1 THE IMPORTANCE OF SYSTEMATIC LITERATURE REVIEWS

In order for a literature review to be considered reliable and fair, record must be kept of how the primary studies were sought, selected and analysed to produce the results. A systematic review is undertaken according to a predefined search strategy which helps reduce bias in the review process.

"*It is important not only to know what we know, but that we know what we do not know.*" (Lao-Tze, Chinese Philosopher)

4.2.2 ADVANTAGES AND DISADVANTAGES

Advantages:

- The predefined methodology reduces bias in the review process [25].
- The literature review is transparent about how conclusions were generated.
- The review can be replicated [26].

Disadvantages [26]:

- Systematic reviews provide only specific answers to specific questions.
- Systematic reviews require significantly more effort than traditional literature reviews.

4.2.3 FEATURES OF SYSTEMATIC LITERATURE REVIEWS

Some of the features that differentiate a systematic literature review from a traditional review are [25], [26]:

- Systematic reviews are initiated by the definition of the research protocol that specifies the research question and the methodology according to which the review will be executed.
- Systematic reviews are conducted according to a predefined strategy that guides the comprehensive search to find all relevant literature.
- The search strategy is documented to ensure repeatability and to enable readers to assess the completeness of the review.

- Systematic reviews use explicit predefined criteria according to which studies are included or excluded.
- Explicit methods of extracting specific information from each primary study.
- Systematic reviews specify the quality criteria according to which each primary study is evaluated.

4.3 Conducting the review

As described in Section 2.2.1, page 9, a three step methodology (summarised in Figure 2) was followed to conduct the systematic review. This section will present the results of the systematic review.

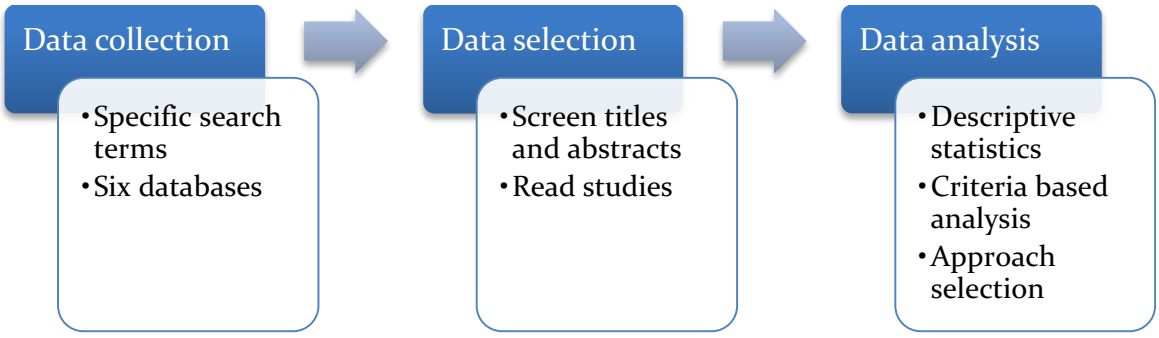


Figure 2: Systematic review methodology

4.3.1 STEP 1: DATA COLLECTION

The research questions we set out to answer through the systematic review are:

1. Which methods/approaches are used to evaluate IS and/or IIS?
2. How and in which context have these methods/approaches been applied?

Due to the very few studies on the evaluation of IIS available in literature, it was decided to cast a wider net and look at the evaluation of traditional IS as well. Studies were identified through searches of Web of Science, Scopus, Academic Search Premier, Emerald, Science Direct and ProQuest Research Library databases. Title, abstract and keyword information were searched using predefined search terms. A list of search terms was constructed based on knowledge gained from the initial literature and the field knowledge of the review team. The database worksheets showing the amount of studies collected from each of the above mentioned databases can be viewed in Appendix A.

4.3.2 STEP 2: DATA SELECTION

The total yield of the combined searches, using the databases and search terms described in Step 1, after duplicates were removed, were 249 publications. Publications were discarded if they were written in a foreign

language. The titles and abstracts were reviewed and publications were discarded if they were either not related to the evaluation of IS/IIS or just mentioned it in passing. This resulted in 106 studies. The list of the 106 included studies is available in Appendix A.

4.3.3 STEP 3: DATA ANALYSIS

The data analysis was broken up into three stages, listed in Figure 2, namely:

1. Stage 1: Descriptive statistics
2. Stage 2: Criteria based analysis
3. Stage 3: Approach selection

First we will present descriptive statistics on the IIS evaluation literature included in the review.

Stage 1: Descriptive statistics

The 106 studies included in our review were individually coded by the authors. This was done in order to standardize the information contained in the studies and to assist in the identification of trends in the literature. The main aspects of the articles that were coded were:

1. The type of paper as well as the publication type. This was extracted in order to identify the target audience of the study in focus and to gain broad insights on the dimensions of the studies.
2. The method/approach used in the article. As previously mentioned the main objective of this review was to identify methods and approaches used to analyse/evaluate innovation systems.
3. The type of innovation system that was analysed/evaluated and its context/discipline. This was extracted in order to connect the method/approach used to the type of innovation system it was applied on in order to identify patterns.
4. The goal of the analysis/evaluation. This again served to provide insights on the types of methods/approaches that are used for specific goals.

Table 7 below shows the different types of publications that the 106 included studies were collected from.

Table 7: Publication types

Publication Types	***Number of studies***
Journal Articles	73
Books	1
Conference Proceedings	20
Online Archives	2
PhD Theses	2
Technical Reports	7
Unpublished Reports	1

Figure 5 is a timeline that shows the amount of studies (included in this review) published per year in chronological order. From this figure it is clearly visible that there has been an increase in studies on IS over the last few years and it also depicts the relatively small number of emerging studies in the area if IIS.

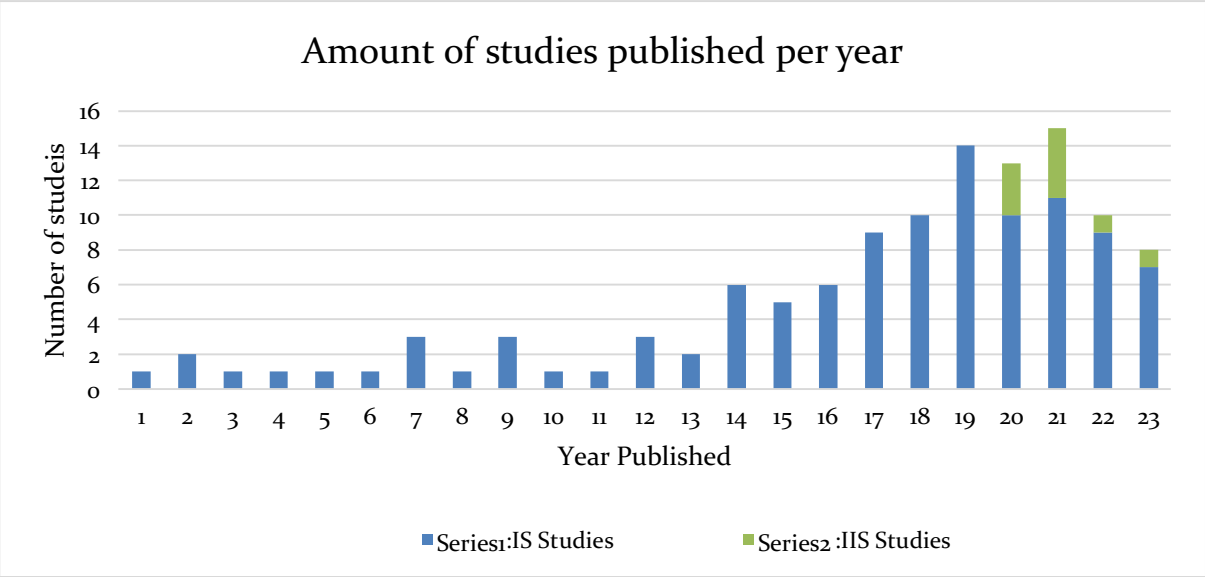


Figure 5: Amount of IS and IIS Studies

The 106 papers were analysed with the use of Atlas.ti software. This enabled the authors to code different methods/approaches. The first iteration served as a scoping opportunity. The identification of methods/approaches was an iterative process that was conducted in a 'learning-by-doing' manner. It became evident that many approaches are based on the same foundational characteristics. All the methodologies described in the review were categorised into nine main methods/approaches. The nine main methods are shortly described below:

(1) Macro-economic level approach (Comparative Approach): The innovation system performance of geographically different innovation systems is compared in order to guide policy development. It considers the stages of development, evolution of the national innovation systems and distinguish between policies in terms of supply-side and demand-side in order to create technological dynamism within the country through means of a comparative perspective between two/more countries. It is a comparative framework used to evaluate innovation policy. The framework starts by identifying activities across sectors where a country could build comparative advantages. Next the innovation chains consisting of both technical and economic interfaces are identified. This evaluation is then used to generate new 'innovation policy' that aims to strengthen the techno-economic network as a whole rather than supporting specific activities [58].

(2) Regime (macro, meso, micro) approach: This approach divides the NIS into three levels namely macro, micro and meso level. The IS actors and functions are categorised into these levels and evaluated based on the requirements of each level [59], [60].

(3) Triple-helix model: This model focuses on three main actors within the IS: academy, industry and government [89].

(4) Systems Dynamics (SD) approach: System dynamics aims to describe the system through both qualitative and quantitative models. This method entails the construction of causal loop diagrams that describe causal assumptions of the system in question and often also include quantitative modelling through a stock and low diagrams. The key concept behind these diagrams is to conceptualised complex behaviours in systems and to model the expected behaviour of systems due to non-linear nature of these systems. These models capture feedback loops and causal thinking and is hugely useful in improving understanding of the nonlinear behaviours of such systems [61].

(5) Component-based (structural) approach: The structural approach entails the identification of system elements such as all the actors, institutions and organisations within the system and understanding the relations between these elements [50].

(6) Function-based approach (also called TIS approach): The functional approach has been identified as one of the approaches most used in the literature which form part of this review. This approach involves the analysis of the system by means of certain activities commonly referred to as 'functions'. Different authors orientate the approach to different focuses and integrate it with other approaches [41], [47].

(7) Component-function-based approach: This approach is an integration between the component-based and functional approach. Lamprinopoulou et al. [62] state that it has been argued in literature that since structures and functions are mutually dependent it is better to follow an integrated approach where the component-based and functional approaches is used in unison.

(8) Data Envelopment Analysis (DEA): It is one of the most mature efficiency evaluations. This method uses mathematical techniques that can use various variables and constraints to evaluate the relative efficiency of Decision Making Units (DMUs). The advantages of the DEA method is that the analysis of the effect of innovation system on the system outputs can provide managers with useful decision information and DEA is very objective [63].

(9) Analytical Hierarchy Process (AHP) Method: The AHP method first entails the construction of evaluation indexes for the overall goals and sub-objectives of a specific program or system and then the AHP method is used to determine the weight of these indexes. This method provides an effective way of simplifying complexity in order to determine the relative importance of the objectives of each process within a system [64]. Table 8 shows which studies applied each of the above mentioned approaches and Figure 7 shows the frequency of studies that applied each method/approach.

Table 8: Studies that applied each of the 9 approaches

Method/ Approach	Studies
Macro-economic level approach	[58],[65],[66],[67],[68] ,[69],[70],[71]
Function-based approach	[47],[41],[72],[73],[74],[75],[76],[77],[78],[79],[80],[81],[82], [83]
Component-based	[84], [85], [86], [87], [88], [89], [90], [91], [92],[53], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [70], [103], [2], [38], [104]
Component-function-based approach.	[105],[106],[107],[108],[109],[110],[111],[112],[113],[36],[114],[115] [62],[116], [117]
Regime (macro, meso, micro) approach	[118],[119],[120],[33], [121],[122],[59]
Triple-helix model	[123],[124]
Systems Dynamics (SD) Approach	[125],[126],[127],[128],[61],[129],[130],[131],[132],[133],[101],[134], [135]
DEA	[136],[137],[138],[63],[139],[140]
AHP	[141],[142],[143],[144]

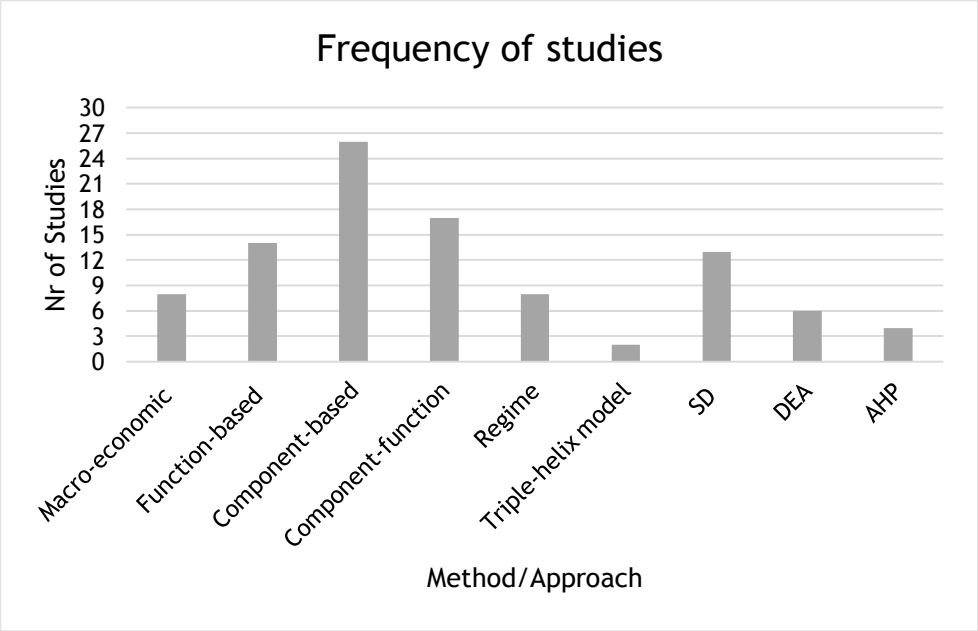


Figure 7: Frequency of studies employing each approach

Stage 2: Criteria based analysis

To compare and draw insight from the different methods/approaches in literature we identified two sets of criteria according to which the methods were analysed. This section comprises the analysis of the main methods/approaches identified from literature. An analytical framework according to which the methods were analysed was defined in Section 2.2.1, page 9.

Appreciating that there is no single optimal evaluation method applicable to all evaluations, the authors constructed a database of different approaches, the context in which they were applied as well as the purpose of each. To enable the comparison of the functioning and applicability of each of the methods/approaches to the current study, each approach was assessed based on whether it meets the criteria for effective evaluation. The result of this evaluation and the applicability of each method/approach to the evaluation of IIS with examples of the application is shown in Table 9.

Stage 3: Approach selection

The analysis of Table 9 revealed that the approaches meeting most of the pre-defined criteria are the functional approach and the component-function-based approach. Each of these approaches are applicable to various actors and both use functions of innovation to analyse complex problems, innovative capacity and the functioning of a system. Both identify system failures by identifying problems that hamper the effective functioning of the system i.e. that hampers innovation in the system under study. The analysis of Table 9 was also used to determine which of these two approaches would be most applicable to the evaluation of IIS. As previously mentioned we defined the requirements for such an approach to be (1) actor-oriented, (2) analysing complex relationships between actors; (3) using rich qualitative data, and; (4) conducting a process focused analysis.

The combination of the component- and function-based approach ensures that it is actor-orientated and seeks to identify complex relations between actors. The approach does require rich qualitative data to be gathered in order to identify how well system functions are performed. The system processes are analysed by means of system functions. Finally, a study was identified from the review in which the component-function-based approach was successfully used to analyse an IIS. Van der Hilst [40] developed a tool based on the component-function-based approach to determine the performance of innovation intermediaries within the agricultural IIS of Vietnam. It was developed by altering the method proposed by Wieczorek & Hekkert [43] to be suitable for the evaluation of IIS.

Table 9: Comparative assessment of identified methods and approaches

	1. Assessment of identified methods and approaches					*2. Evaluation of applicability to IIS*				
Method/ Approach	***Mixed data***	***Internal and External analysis***	***Various actors across different levels***	***Integra-ted analysis***	***Gap analysis***	***Actor-orientated***	***Analyse Complex Relations***	***Collect rich qualitative data***	***Process analysis***	***Studies where methods were applied to evaluation of IIS.***
Macro-economic level approach	✓			✓	✓			✓		None
Component-based approach			✓		✓	✓	✓	✓		[145] ,[38], [42]
Function-based approach		✓		✓	✓		✓	✓	✓	[40]
Component-function-based approach.		✓	✓	✓	✓	✓	✓	✓	✓	[40]
Regime (macro, meso, micro) approach	✓		✓	✓		✓		✓		None
Triple-helix model	✓		✓		✓	✓		✓		None
Systems Dynamics Approach	✓		✓	✓		✓	✓		✓	None
DEA Method	✓									None
AHP Method					✓					None

4.4 Chapter summary

The goal of this review was to identify a method/approach that could serve as a basis from which to develop a tool to evaluate UTIID projects. To that end a review of the extant IS evaluation literature was conducted. This review identified nine methods that are most frequently used throughout literature. Each method was evaluated according to a pre-defined criteria and the results described in Stage 3 shows that the component-function-based approach is the most appropriate approach from which to develop an evaluation tool. It is an actor-oriented approach that enables the identification of the different actors within the system, demand-side, supply-side and the intermediaries. It focuses on the complex relations between actors in order to evaluate knowledge and capability transfer. The combined structural and functional approach is best for the evaluation of IIS as the functions of a system can only be improved by altering one or more components. Every function is evaluated from the perspective of the components [40].

CHAPTER 5 ANALYTICAL FRAMEWORK: COMPONENT-FUNCTION APPROACH

Phase 1: Problem Statement & Systematic Review	Phase 2: Framework	Phase 4: UTIID evaluation tool
	Phase 3: Case Studies	

In Chapter 4 the component-function approach was selected as the most appropriate approach for the evaluation of IIS. Chapter 5 provides an overview of this approach from literature and this serves as the basis from which an evaluation tool is constructed.

Chapter 5 intends to achieve the following:

- Introduce the five stages of the analytical framework.
- Describe what each stage of the analytical framework entails.

Based on the framework proposed by Wieczorek and Hekkert [43], the analytical framework will consist of five stages, shown in Figure 8.

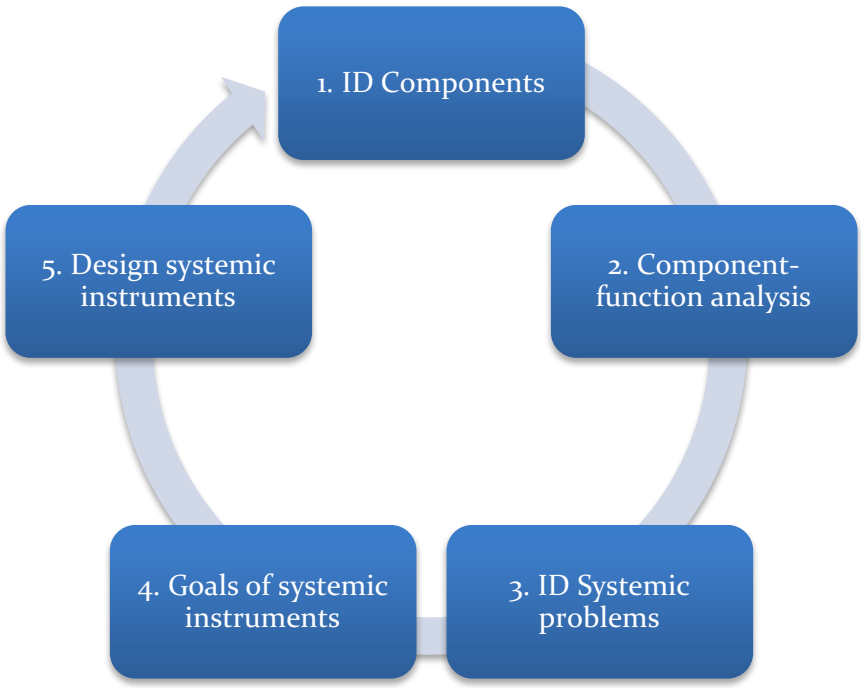


Figure 8: Framework for the analysis of innovation systems [43]

The following sections will describe each stage, drawing from literature to introduce the analytical framework.

5.1 Stage 1: Identify components

The component-based approach highlights that the economy is a system made up of various actors, networks and institutions [43]. This approach helps to identify the key components of the innovation system. It also aids with the identification of missing actors, networks or institutions and it can be used to identify the quality/capabilities of the system components [146].

The following sub-sections briefly discuss what each component entails, specifically in the context of UTIID projects. These are mainly based, on but not limited to, the work done by Foster & Heeks [38] and Tijssen & Dijksterhuis [23].

5.1.1 INNOVATION

Literature makes the distinction between two main schools of technical innovation. Firstly, there is the improvement of an existing design, product, process and/or strategies, and secondly the introduction and implementation of a new/novel concept that significantly differs from past designs [147].

Innovation theory describes two prompts of innovation; technology-push and market-pull. The first describes new technological innovations introduced to the market, the second refers to innovations that are developed in response to customer demand. Innovation can be classified according to the "type" of innovation. We will make use of two classifications found in literature, namely "product innovation" and "process innovation" [148]. The former is defined as new or improved products or services, while the latter refers to improvements in the process of making products and services.

Innovation can also be classified based on the degree of newness and impact. We will classify the degree of newness on a scale between the two extremes; namely, incremental and radical innovation. Incremental innovation refers to the improvement of an existing design. The design of a single component changes, but the core design and links between components remain the same. Radical innovation establishes a new/novel design that significantly differs from past practice in terms of the core designs and the architectural links between components [147]. Impact can be classified as either disruptive innovation that establishes a new market that displaces existing markets or sustaining innovation that perpetuates existing products/services and processes [149]. Christensen [150], described the qualities of disruptive innovations that bring about social change, which can be used to guide the classification of impact. Three of these qualities are: (1) these innovations bring about systematic social change by means of replication and scaling; (2) they meet a need which has not been met yet or that has been "overserved" by unnecessarily complex solutions, and (3) they offer cheaper and less complex products and services.

In a study conducted by George et al. [6], they concluded that both top-down and bottom-up processes are vital in the introduction and driving of inclusive innovation initiatives. We argue that this is also true for UTIID projects. Kruss & Gastrow [15] emphasised the importance of a project champion driving the UTIID projects

(top-down), and Ansari et al. [39] put the end-users (communities) forward as key contributors to the innovation process by providing insights on actual needs and context (bottom-up).

We also considered the dominant university mission behind driving the innovation i.e. the project objectives. These were classified according to the three main university missions namely education, research and community engagement. Table 10 summarises the proposed approach to analyse the innovation component of an UTIID project.

Table 10: Approach to assess innovation [17], [40], [147]

Component	*Innovation*
Main focus	• Incremental innovation with a focus on diffusion processes. • Local needs-oriented innovation as appropriation, configuration, use, variation, domestication. • Demand-driven and context driven innovation. • Reverse innovation.
Identify	• Type of innovation (product/service, process or combination). • Degree of newness (incremental, radical). • Impact (disruptive, sustaining) • Intention of the innovation (development, education, research). • Driving mechanism, sustainability, possibility to scale. • Manufacturing and distribution • Barriers and interactions between university research, community engagement and commercialisation. • Business development.

5.1.2 ACTORS

Actors are the components that are involved in innovation activities. These may include, but are not limited to firms, universities and research institutes, institutions and organisations [38]. As this study is specifically focused on UTIID projects, the first set of actors involved are university staff and students. The second set of actors are the members of the marginalised community. These members are involved in varying aspects of the innovation process.

5.1.2.1 COMMUNITY INVOLVEMENT

Innovation for inclusive development is rooted in a participatory manner. The involvement of the community is necessary for any developmental intervention or project to be sustainable. The ultimate objective of innovation for inclusive development projects should be to empower communities to identify and deal with societal challenges by utilising their resources effectively [151].

Pretty et al. (1995) cited by Kuruvilla et al. (2015) presented a typology of community involvement, also called community participation:

- Passive participation: The community participates by being told what to do and/or what will happen.
- Participation in information giving: The community participates by providing information during surveys, interviews or other extractive approaches.
- Participation by consultation: The community is consulted and participate in this manner.
- Participation for material incentives: The community provides resources such as labour in return for material incentives.
- Functional participation: The community comes together to meet goals predetermined by the project.
- Interactive participation: The community participates in shared analysis, planning and execution of projects.
- Self-mobilisation: The community initiates its own interventions.

5.1.2.2 DEGREE OF COMMUNITY INVOLVEMENT

Adapting the process view suggested by Heeks et al. [37], we classified the degree of community involvement as either involved in the 'design', 'development' or 'implementation' of the innovation. The adaption can be seen in Figure 9 below.

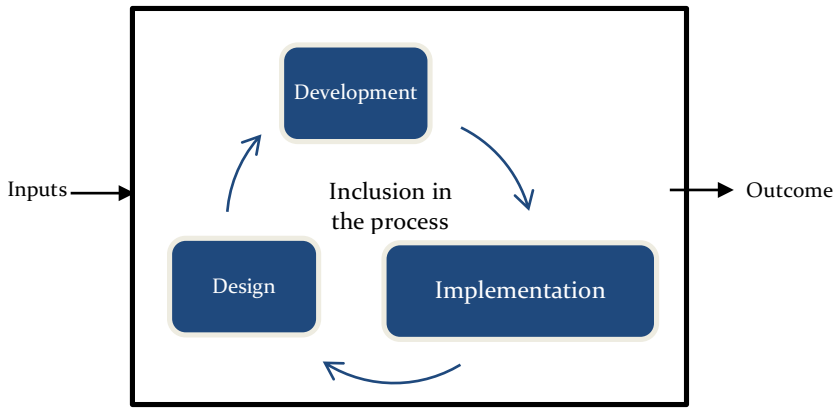


Figure 9: Process view of innovation (adapted from Heeks et al. [37]

5.1.2.3 INTERESTS IN INVOLVEMENT

Shared interests are the most important characteristic that can pull people together and encourage them to get involved in innovation for inclusive development projects [151]. White [151] distinguished between four overarching types of involvement. These are summarised in Table 11 below. The first column describes the form of involvement, the second describes the top-down interest in involvement from those who initiate the project. The third column describes the bottom-up interest in involvement from the community and the fourth column describes the overarching function of each type of involvement.

Table 11: Interests in participation [151]

Form	***Top-down***	***Bottom-up***	***Function***
Nominal	Legitimation	Inclusion	Display
Instrumental	Efficiency	Cost	Means
Representative	Sustainability	Leverage	Voice
Transformative	Empowerment	Empowerment	Means/End

5.1.2.4 ADVANTAGES OF COMMUNITY INVOLVEMENT

Community involvement beyond the 'implementation' phase is an important learning and capacity-building process. If the marginalised community is involved in decision-making, they become empowered. An empowered community can take initiative, show leadership and utilise resources to solve societal problems. There are several advantages to community involvement, the list below summarises some advantages identified from literature [151], [152]:

- Sustainability: Community involvement is a necessary to ensure the continuity of innovation for inclusive development projects.
- Efficiency: Community involvement can ensure effective utilisation of resources that are available.
- Self-reliance: The participation of community members prevents the community from becoming dependent on the 'external' project.
- Coverage: Community involvement improves the diffusion of benefits to the community.

5.1.2.5 DISADVANTAGES OF COMMUNITY INVOLVEMENT

The literature also highlights some arguments against getting the community involved in interventions. One such argument is that getting community members involved is a tedious and timely process. It takes time to build relationships with the community members, and their involvement can delay and slow down the project progress. There is also the issue that more human and material resources are required in order to effectively get the community involved, which results in extra costs. Community involvement is also a process that will look different for every project, it therefore creates uncertainty in the project timelines and projected outputs [16].

5.1.2.6 ACTOR ASSESSMENT

Table 12 summarises the proposed approach to analyse the actors in an UTIID project.

Table 12: Actor assessment [17], [40]

Component	*Actors*
Main focus	• Non-traditional, less formal, demand-side innovators. • Low income consumers. • Partners, beneficiaries.

	• Intermediaries: Innovators that apply adaptive and incremental innovation to compensate for the frequent mismatch between externally innovations and internal needs [38].
Identify	Actors in the UTIID projects and their roles (contributions): • Project champions. • Student involvement. • Other departments (same university). • Other SA universities. • International universities. • Community members. • Government. • Businesses. • NGO's/ Non-for-profit organisations.

5.1.3 RELATIONS

Innovation systems describe the interactions of system actors with specific emphasis on how innovations are orientated within the system due to changes in relations that occur over time. George et al. [6] argue that the implementation of novel forms of partnerships and networks connecting marginalised communities to opportunities is one of the key processes required for inclusive development.

Kruss and Gastrow [15] conducted a study on the relationship between universities and marginalised communities. One of the objectives of their study was to map the interactions of academics in universities. They identified four different complex groupings of types of relationship patterns: (1) "socially responsive, research- and teaching-oriented"; (2) "teaching-oriented community and research-oriented firm interaction pattern"; (3) "development-oriented service pattern", and (4) "firm and user teaching-and research-orientated pattern". From the pilot study conducted by Grobbelaar et al. [18] in 2014, we identified the following list of actors with whom the UTIID projects interact: other departments of the same university, other universities (SA), international universities, communities, the government, business enterprises and NGO's. Kruss and Gastrow [15] also provided a comprehensive summary of the various ways in which partnerships serve as enablers contributing to inclusive development. Amongst others the list includes funding, strategic leadership, equipment, facilities and expert advice. Table 13 summarises the proposed approach to analyse the relations within an UTIID project.

Table 13: Assessment of interactions [17], [40]

Component	*Interactions*
Main focus	The necessity (but not limited to) of informal, loose and socialised relations and partnership engagement.
Identify	• Nature of relationships (formal, informal). • Collaborative networks and partnerships. • Partner contributions (funding, strategic leadership, equipment, facilities, expert advice).

	• Mode of community interaction (e.g. cooperatives).

5.1.4 INSTITUTIONS

Institutions refers to the routines, culture, norms and regulations that are either explicitly developed by the actors, or have evolved spontaneously [51], [153]. Institutions influence both the functioning of individual actors and the system as a whole. There exists a distinction between formal and informal institutions. Formal institutions, also called hard institutions, are codified rules that are imposed by some authority. Informal institutions, also called soft institutions, are more naturally shaped by the interaction of actors and are more tacit [154]. Institutions are sector specific and will differ greatly from one sector to the next [155]. Table 14 summarises the proposed approach to analyse the institutions that have an impact on UTIID projects.

Table 14: Assessment of institutions [17], [40].

Component	*Institutions*
Main focus	Complex mixture of both formal and informal institutions • Indirect impact of formal institutions. • Informal institutions are very important at local level (also including possible negative impact).
Identify	• University policy that governs the inclusive innovation project. • University incentive and reward systems for the project. • Other external support systems. • Intellectual property and models of ownership. • Arranging the UTIID projects and community engagement (e.g. NGO's, cooperatives, community, church).

5.1.5 INFRASTRUCTURE

Literature provides several different definitions to what "infrastructure" covers. In this study we will use the proposition put forward by Wieczorek and Hekkert [43] to use three categories of infrastructure namely physical infrastructure, knowledge infrastructure and financial infrastructure. Physical infrastructure refers to tangible infrastructure that forms part of these projects such as buildings, roads, machinery and equipment. Knowledge infrastructure comprises the technical know-how, expertise, knowledge and information. Financial infrastructure refers to the availability of finance for innovation by means of grants, loans and donations etc.

Table 15: Assessment of infrastructure [43]

Component	*Infrastructure*
Main focus	The management of these infrastructure.
Identify	• Physical infrastructure (Machinery, equipment, facilities etc.)

	• Knowledge infrastructure (Knowledge, technical know-how etc.) • Financial infrastructure (grants, loans, donations etc.)

5.2 Stage 2: Component-functional analysis

The idea behind the function-based approach is that a system consists of a set of functions that has to be fulfilled in order to serve the purpose of the system. The inducement of innovation processes is the most significant purpose of an innovation system. The system performance and functioning can be conveyed in terms of how well the different system functions have been fulfilled [53]. These system functions and their roles in this research will be discussed in the following sub-sections.

The function-based approach helps the analyst identify the determinants of change in the system. This is done by grasping the dynamics of the system, i.e. understanding the activities and functions within the system that enables the system to achieve its desired goals [53]. The functional analysis emerged as a complementary approach to the component approach [62]. The functions refer to key processes in a technological innovation system that support structural components. The functional analysis reveals the state of an IS at a specific moment in time. The functional approach aims to evaluate a system by identifying blocking mechanisms that hinder the diffusion of technology in (typically) one country and to then derive policy recommendations [41], [72]. The main advantages of this approach is that it places emphasis on what is actually achieved in the system rather than focusing on the structural elements and it enables the identification of system borders. The system then consists of all the structures/components that influence one/more of the system functions [156].

The functions of the IS can be described by a non-linear model, all functions are interdependent and there exists multiple interactions between functions. Systemic innovation and structural change is dependent on functions that positively influence each other [157]. Functional fulfilment results in positive feedback loops that helps increase the development and acceptance of new technologies [157].

Several authors have argued that the functional analysis should be coupled with the component analysis as functions cannot be altered without altering structural components [41], [43]. They suggest that the identification of the functional composition of a system should be followed by an assessment of every function from the perspective of four structural components; namely, actors, relations, infrastructure and institutions. The aim of this assessment is to provide either explanatory or policy reasons for insufficiencies in functions [43].

Stage 2 consists of two parts. Firstly, each function's performance is evaluated based on a set of indicators collected from the literature, and secondly it is vital to identify the components that cause insufficiencies in functions or that cause the absence of a function. The following sub-sections briefly discuss what each function entails.

5.2.1 F1: ENTREPRENEURIAL ACTIVITY

An IS cannot exist without entrepreneurs. Entrepreneurs play the essential role of transforming the potential into action in order to produce and capitalise on new business opportunities [40]. In the context of UTIID's the project champions fulfil the role of the 'entrepreneur'.

Literature refers to two modes of entrepreneurs; they can be entrants that identify the potential of new business ventures in new markets or incumbent firms who take advantage of new developments by adapting their business strategy. The experimentation conducted by entrepreneurs results in many forms of learning and reduces uncertainties in terms of technologies, markets and applications [40], [53], [158].

A system in which all the functions are sufficiently performed will incubate an environment that promotes and enables entrepreneurial activity. Such a well-functioning system is essential for the success of the entrepreneur. Therefore, a key indicator of system performance is the presence of entrepreneurs [53]. A single entrepreneur is incapable of fulfilling all system functions and must therefore decide which functions to fulfil himself and which to delegate to other organisations (and which organisations these should be) [159].

Entrepreneurial activity can be analysed by identifying the amount of new entrants into the system, the amount of strategical adaptations and the amount of experiments conducted with the innovation [53]. Table 16 summarises the indicators used to analyse entrepreneurial activity.

Table 16: Analysing entrepreneurial activity [36], [46], [43] ,[155].

Function	***Indicators***	***Diagnostic questions***	***Structures***
F1: Entrepreneurial activity:	Project champion	• The functions that the project champion fulfils. • Mode of entrepreneurship (entrants or incumbent firms). • Whether other functions (not fulfilled by project champion) are delegated and to whom.	• Actors • Institutions • Interactions • Infrastructure
	Involvement	• When and how is the excluded group involved in invention, design, development, production, distribution or use.	
	Experimentation	• Extent of experiments conducted (tests/pilots).	
	Businesses	• Are there businesses involved, and the extent of involvement.	

5.2.2 F2: KNOWLEDGE DEVELOPMENT

In the modern economy, learning is considered the most important process and knowledge the most important resource [160]. The successful development of an innovation is primarily dependent on how well functions 2 (knowledge development) and 7 (creation of legitimacy) of the system is developed [53]. It is therefore essential that R&D is performed and knowledge is developed [77]. We can make a distinction between the type of knowledge and the sources of knowledge development. Bergek [158] lists a few examples of 'types' of knowledge such as design, technological, logistics etc. In the context of UTIID projects we distinguish between technical knowledge, business knowledge and social knowledge. The sources of knowledge development entails "learning-by-doing", "learning-by-interacting", and "learning-by-using" [38].

Hekkert et al. [53] suggested three indicators that can be used to map this function; namely, patents, R&D projects and investments in R&D. According to Van der Hilst [40] these indicators will not be useful in most developing countries due to the generally informal circumstances under which experimentation occurs and mostly underdeveloped institutions that regulate property rights. We would also like to highlight that these indicators do not reflect whether the innovations aim to promote inclusive development and are therefore not applicable to the evaluation of UTIID projects.

These projects are based on the notion that universities have the responsibility to serve communities, but also that the communities can contribute knowledge that can be of value to the university [15].

Innovation is brought about by different categories of learning. Foster & Heeks [38] highlights three types: "learning-by-doing", "learning-by-interaction" and "learning-by-using". "Learning-by-doing" refers to individuals who develop knowledge by participating in production processes. "Learning-by-interaction" refers to learning that emerges from engaging and working with other actors in the system. "Learning-by-using" relates to the changes that actors must make in order that new technologies are suitable for their particular purpose. Table 17 summarises the indicators used to analyse knowledge development.

Table 17: Analysing knowledge development [40].

Function	***Indicators***	***Diagnostic questions***	***Structures***
F2: Knowledge development:	Sources and process of knowledge development	• What and who are involved in the process of knowledge development? • Did the process include the excluded group? How did learning take place? (learning-by-doing, learning-by-interaction, learning-by-using)	• Actors • Institutions • Interactions • Infrastructure
	Knowledge infrastructure	• Expertise, know-how and strategic information that is available. • Type of knowledge (technological, business, tacit and codified)	

	Research collaboration	• Collaboration between the different sources of knowledge. • Collaboration between the sources and users of knowledge.	

5.2.3 F3: KNOWLEDGE DISSEMINATION

Knowledge and information needs to be transferred from knowledge producers to knowledge users in order for it to add value [40], [52]. Networks exist for the exchange of knowledge and information therefore network activity can be seen as a requirement for the different types of learning.

This function can be analysed by identifying the amount of workshops and conferences that are held regarding the specific technology focus under discussion. The network size and intensity can also be considered [53]. Table 18 summarises the indicators used to measure knowledge diffusion.

Table 18: Analysing knowledge dissemination [40], [52]**.**

Function	***Indicators***	***Identify***	***Structures***
F3: Knowledge diffusion/ dissemination	Focus of diffusion	• Top-down vs bottom-up? Is knowledge diffusions aimed at benefiting the marginalised group? Is knowledge development demand driven?	• Actors • Institutions • Interactions • Infrastructure
	Partnerships	• Are there partnerships forming between various actors?	
	Space for dissemination	• The methods used to create spaces for knowledge dissemination (workshops, focus groups etc.).	

5.2.4 F4: GUIDANCE OF SEARCH

This function encompasses the activities within an IS that provides insights and clarity of the specific wants and needs of the technology users [158]. Function 2 (knowledge development) is seen as the development of technological variety and Function 4 (guidance of research) is regarded as the process of selection, responsible for selecting the specific focus area for further investment [53].

Function 4 can be analysed by identifying and mapping the specific targets concerning the use of the technology that was set by specific industries or the government. Another indicator used to analyse Function 4 is the amount of articles published in professional journals [53]. The number of articles published is,

however, not necessarily a suitable indicator for UTIID projects. We therefore refer to the set of indicators suggested by Bergek [158]. These indictors aim to enable the analyst to make a compound judgement of the function. Table 19 summarises the indicators used to analyse guidance of search.

Table 19: Analysing guidance of search [158].

Function	*Indicators*	*Identify*	*Structures*
F4: Guidance of search	Targets	• Which targets are being set regarding the use of the technology, are they realistic, are there strategies in place to meet these targets?	• Actors • Institutions • Interactions • Infrastructure
	Recognised constraints	• What are the main constraints that inhibit or block the success of the projects?	
	Belief in growth potential	• Does the project team have a belief in the growth potential? • Articulation of interest from marginalised community. • Vision and strategy.	

5.2.5 F5: MARKET FORMATION

Function 5 describes the process of creating protected spaces for the introduction of new technologies. This needs to be done as new innovations are not necessarily sufficiently adapted to meet the need it was designed for [156]. This can be accounted for by the creation of temporal niche markets or by offering a competitive advantage [77], [161].

This function can be analysed by identifying the amount of niche markets that have emerged, favourable tax regimes and new environmental standards that might induce the development of environmental technologies [53]. The "Inclusive Innovation Readiness Index" is also proposed as a method to analyse market formation. This index emphases the infrastructure required for an "inclusive innovation". We therefore argue that if this infrastructure is in place the innovation would be "market-ready", and, if not, they serve as barriers to entering the market. These include policy, institutional-, human-, financial- and technological infrastructure as well as the demand for the innovation [37]. Table 20 summarises the indicators used to analyse market formation.

Table 20: Analysing market formation [37].

Function	*Indicators*	*Identify*	*Structures*
F5: Market formation	Institutional infrastructure	• Incentives to promote market formation (favourable tax regimes, environmental standards etc.)	• Actors • Institutions

		• Collaborative organisations and infrastructures to support innovation for inclusive development.	• Interactions • Infrastructure
	Market-readiness	• Human infrastructure: Do all actors have efficient knowledge and skills required. • Physical infrastructure: Dissemination and access to the technology required for the innovation. • Financial infrastructure: Access to capital. • Demand: The existence of incentives for innovation for inclusive development. • Is the project creating spaces for innovations to become market-ready? • Instruments for market formation (public-private partnerships, incubators etc.).	

5.2.6 F6: RESOURCE MOBILISATION

This function encompasses all activities that provide support to access human and financial resources. Knowledge development for a specific technology is dependent on the provision of sufficient resources, therefore F6 is a prerequisite for F2 (Knowledge development).

Hekkert et al [53] stated that the analysis of Function 6 is complex, there are no particular indicators that can be used to map this function. They recommend performing interviews with the main actors in the system to determine whether they experience problems regarding access to resources. Table 21 summarises the indicators used to analyse resource mobilisation.

Table 21: Analysing resource mobilisation [40]**.**

Function	***Indicators***	***Identify***	***Structures***
F6: Mobilisation of resources	Access to capital	• Does the project have access to capital? • Where does this come from? • Is the funding sustainable?	• Actors • Institutions • Interactions • Infrastructure
	Platform or stand-alone	• Is the project part of an innovation platform where resources can be pooled from?	
	Public spending	• What share of the project budget is spent on public spending?	

5.2.7 F7: CREATION OF LEGITIMACY

This function encompasses all activities that support the increased acceptance of a technology. The introduction of new technologies will often receive opposition due to conflicts between old and new products [49]. In that case, legitimacy needs to be created for a new technological development path [158]. This can be done by introducing a new technology, influencing the allocation of resources and offering a competitive advantage such as favourable tax regimes. Function 7 (creation of legitimacy) can be analysed by tracking the behaviour of interest groups and their "lobby actions" [40]. Partnerships formed between different actors promotes the creation of legitimacy. Partnerships result in a platform where resources can be shared, Resource mobilisation (F6) and result in future investments (F4). Table 22 summarises the indicators used to analyse the creation of legitimacy.

Table 22: Analysis of creation of legitimacy [40]**.**

Function	***Indicators***	***Identify***	***Structures***
F7: Creation of legitimacy	Group confidence	• Do project outputs have good reputation with the users of the product / service (quality, on-time etc.)	• Actors • Institutions • Interactions • Infrastructure
	Commitment	• Does the project show commitment to the advancement of the excluded group? • Are there agreements/ memorandums set up that dictate the commitment of the university.	
	Partnership forming	• Are there partnerships forming? (government, NGO's etc.) Is this sustainable?	
	Business plan assessment	• Has the business plan been assessed? • By who? • Do investors have sufficient capabilities to assess business plans?	
	Resistance to change	• Is there resistance to change from the marginalised community?	

5.3 Stage 3: Identify systemic problems

Systemic problems refer to factors that inhibit the development of innovation systems. These problems are connected to system components. This stage starts with the identification of functions that are not being properly performed.

Analytical framework

The method used to identify systemic problems analysis builds upon a methodology defined by Negro et al. [162]. Their approach was as follows: they used empirical work and retrieved historical events related to a technological development from various sources, each event was then allocated to a specific systems function. The functions were then measured by counting the instances of each event type over time. The approach was slightly altered to meet the requirements of our analysis. Data was gathered by means of interviews. The 'events' are the indicators listed in Table 16 - Table 22 (see Table 23 for the compiled list of indicators). They are measured on whether these indicators are 'present' in each of the UTIID projects or not. When an indicator is present, it has a positive contribution to the UTIID project success and represents a positive score. Some indicators are, however, not present, and their absence is seen as a limiting factor therefore the absence of an indicator is counted as a negative score. All indicators are weighed the same. Each function has a highest possible score. The positive and negative scores are added to each other and the comparison between the result and highest possible score for a specific function is used to identify areas for improvement. Other studies have used a scale of: 0 = Absent, 1 = Very weak up to 5 = Strong [43], but in order to avoid being biased, this study will classify Absent to Weak as "not present" (-1) and Moderate to Strong as "present" (+1) and indicators that are moderately present are classified as moderate and given a score of 0. We argue that this is sufficient as the aim is to help the projects identify the main problem areas.

Table 23: Indicators for understanding the nature of system functions (adapted from [162]**)**

Function	***Indicator***	***Value***
F1: Entrepreneurial activity *High score: 4*	- Project champion - Moderate project champion - No project champion	+ 1 0 - 1
	- Community involvement (Design, Development and Implementation). - Moderate community involvement (Two of the phases) - No community involvement (No involvement/ only involved in implementation)	+ 1 0 - 1
	- Experimentation - Some extent of experimentation - No experimentation	+ 1 0 - 1
	- Partnerships with businesses - Businesses are moderately involved - No businesses involved	+ 1 0 - 1
F2: Knowledge development	Knowledge infrastructure:	

High score: 2	- Quality expertise, know-how and strategic information - Moderate knowledge infrastructure - Weak/no knowledge base	+ 1 0 - 1
	- Research collaboration - Community is moderately included in research - No research collaboration	+ 1 0 - 1
F3: Knowledge dissemination *High score: 3*	- Strong partnerships - Moderate partnerships - Weak/no partnerships	+ 1 0 -1
	- Knowledge development is demand-driven. - Knowledge development is moderately demand-driven. - Knowledge development is top-down (not demand-driven).	+ 1 0 -1
	- Space for knowledge dissemination (Workshops, training, focus groups etc.) - Moderate space created for knowledge dissemination. - No space created for knowledge dissemination.	+ 1 0 - 1
F4: Guidance of search *High score: 3*	- Targets set regarding the use of the technology. - Vague targets for the use of technology. - No targets, ad hoc implementation.	+ 1 0 - 1
	- Well-articulated vision and belief in growth potential. - Some vision and moderate belief in growth potential. - No vision and no growth potential.	+ 1 0 - 1
	- Articulation of interest from marginalised community.	+ 1

	- Some interest from marginalised community. - No interest from marginalised community.	0 - 1
F5: Market formation *High score: 5*	- Incentives to promote market formation. - Some incentives to promote market formation. - No incentives.	+ 1 0 - 1
	- Existing market. - New market must be created.	+ 1 - 1
	Business plan assessed? - Yes - No	 + 1 - 1
	- Sufficient human infrastructure - Insufficient human infrastructure	+ 1 - 1
	- Sufficient policy infrastructure - Insufficient policy infrastructure	+ 1 - 1
	- Sufficient technological infrastructure - Insufficient human infrastructure	 + 1 - 1
	- Sufficient financial infrastructure - Insufficient financial infrastructure	+ 1 - 1
F6: Mobilisation of resources *High score: 3*	- Sufficient financial infrastructure - Moderate financial infrastructure - Insufficient financial infrastructure	+ 1 0 - 1
	- Public spending - No public spending	+ 1 - 1
	- Platform from which resources can be pooled. - Stand-alone project.	+1 -1
F7: Creation of legitimacy *High score: 3*	Are there agreements, memorandums set up to dictate the commitment of the university to the community? - Yes	

	- No	+ 1 - 1
	Do project outputs have a good reputation? - Yes - No	 + 1 - 1
	- Partnerships (formal/informal) forming. - No partnerships	 + 1 - 1
	- No resistance to change, community adopts the innovation. - Moderate adoption of innovation with some resistance to change. - Resistance to change.	+1 0 -1

The systemic problems are related to the components of the system; the system cannot function properly if there are problems with the components and their attributes; if some of the components are missing or there are issues with its properties or capabilities (actors) [163]. Wieczorek and Hekkert [43] therefore argue that the explanations for why and innovation system does not function properly can be found by analysing the system components from two perspectives: (1) whether the components are present or absent, and (2) whether there is a problem with the properties such as their capabilities or quality. Wieczorek and Hekkert [43] summarised a list of systemic problems from literature and conceptualised a set of systemic problem categories. These are summarised in Table 24 below.

Table 24: Categories of systemic problems summarised from Wieczorek and Hekkert [43]

Structure	***Conceptualised systemic problem types***	***Description***
Actors:	Presence	• Missing actors
	Capabilities	• Weak absorptive (learning) capacity • Inability or weak competency to articulate needs/demands • Inability or weak competency to develop strategies
Interactions:	Presence	• Weak or missing interactions due to: o Lack of trust o Perceived distances between actors o Opposing objectives
	Quality	• "Strong" network problems

		○ Strong actors provide wrong guidance to other actors • "Weak" network problems ○ Weak interactions between actors that inhibits knowledge diffusion learning
Institutions:	Presence	• Missing institutions
	Capacity	• Insufficient or poor institutions (hindering innovation)
Infrastructure:	Presence	• Missing infrastructures
	Quality	• Insufficient or poor infrastructure

It is important to note that these categories do not suggest that in order for a system to perform effectively all these types of structures have to be present. It simply serves as a useful theoretical typology that can be applied to the assessment of systemic problems [43]. The component-function analysis conducted in Stage 3 is used to identify systemic problems. The component-function analysis starts by identifying weaknesses within functions, and these weaknesses are then analysed from a structural perspective in order to determine whether they are related to specific structures. After specifying whether the problem is related to actors, interactions, infrastructure or institutions, the next step is to determine whether it is caused by missing structures or due to the structure's weak capacity [43].

5.4 Stage 4: Goals of systemic instruments

Stage 4 entails the selection of processes and tools to target systemic problems and improve the functioning of the system. These tools are called "systemic instruments" [164]. These systemic instruments should aim to accomplish a set of goals. These goals are linked to the systemic weakness categories highlighted in Stage 3. The goals aim to address the weaknesses and thus influence overall system functioning. Several of the systemic instruments centre around the notion of improving dialogue, vision and strategy development, experimentation and the articulation of demand[165]. Systemic instruments are therefore a set of tools specifically designed for a specific innovation system [43]. Table 25 below describes the systemic instrument goals and the link between them and systemic weaknesses.

Table 25: Systemic instrument goals adapted from Wieczorek and Hekkert [43]

Structure	***Conceptualised systemic problem types***	***Description***	***Goal of systemic instruments***
Actors:	• Presence	• Missing actors	• Induce and stimulate the participation of several actors
	• Capabilities	• Weak absorptive (learning) capacity	• Create spaces where actor capabilities can be improved

		• Inability or weak competency to articulate needs/demands • Inability or weak competency to develop strategies	
Interactions:	Presence	• Weak or missing interactions	• Stimulate and induce interactions between diverse actors
	Quality	• "Strong" network problems • "Weak" network problems	• Block ties that are either too strong or too weak.
Institutions:	Presence	• Missing institutions	• Stimulate the presence of hard and soft institutions
	Capacity	• Insufficient or poor institutions (hindering innovation)	• Do not allow institutions to be too weak
Infrastructure:	Presence	• Missing infrastructures	• Stimulate and induce the presence of different infrastructures
	Quality	• Insufficient or poor infrastructure	• Make sure that the infrastructure is of acceptable quality.

5.5 Stage 5: Design systemic instruments

In order to meet the goals of the systemic instruments listed in Stage 4, a set of tools can be suggested from literature. These tools/instruments aim to create spaces for or induce the occurrence of system functions. Systemic instruments are integrated and designed for a specific innovation system.

Table 26: Systemic instruments adapted from Wieczorek and Hekkert [43]

Goal of systemic instruments	***Systemic instruments***
• Induce and stimulate the participation of several actors.	• Focus groups; feedback sessions; workshops. • New types of partnerships. • Interactive actor involvement techniques.
• Create spaces where actor capabilities can be improved.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions.
• Stimulate and induce interactions between diverse actors.	• Innovation platforms; collaborative research programmes; conferences.

	• Bridging institutions (community liaison, local NGO).
• Block ties that are either too strong or too weak.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Programme assessment and monitoring.
• Stimulate the presence of hard and soft institutions.	• Memorandum/agreement; obligations; articulation of commitment.
• Do not allow institutions to be too weak.	• Focus groups; feedback sessions. • Awareness campaigns; information campaigns.
• Stimulate and induce the presence of different infrastructures.	• Knowledge and financial infrastructure needs to be put in place in order to construct a business model. • Access to capital through grants/loans/funding; various business models.
• Make sure that the infrastructure is of acceptable quality.	• Grant, loans/funding to incentivise UTIID project and to employ full time staff members.

The component-functions analysis (Stage 2) therefore provides a descriptive overview of the current performance of a system and identifies problem areas within the system (Stage 3). The above mentioned goals complement the component-function analysis by providing tools and support policy development to address the issues identified during the component-function analysis (Stage 4 and 5). These systemic instruments describe what tools/instruments should do in order to create spaces for or induce the occurrence of system functions.

5.6 Chapter summary: Analytical framework

This chapter provides a theoretical overview of the component-function approach, specifically the analytical framework developed by Wieczorek and Hekkert [43]. The analytical framework is made up of five stages. The analysis starts by identifying the components of the system (stage 1). This is followed by the coupled component-function analysis (stage 2) in order to measure system performance. Stage 3 entails the identification of system failures. These failures inhibit/block learning and innovation by actors and can be classified based on the type of failure (presence or capacity). These failures are linked to system components. These blocking mechanisms can then be overcome by means of systemic instruments that aim (Stage 4) to influence the components and connections within a system in order to strengthen the functions (Stage 5). The five stages of the analytical framework can therefore be summarised as shown in Table 27.

In the next chapter, the analytical framework is applied to 16 case studies in order to test the applicability of the approach to the evaluation of UTIID projects and to start building up a typology of system failures and proposed systemic instruments for UTIID projects. This chapter also provides an overview of the current state of monitoring and evaluation in these projects and constructs an input, output and outcome typology.

Table 27: Analytical framework adapted from Wieczorek and Hekkert [43]

Stage 1: Identify components	*Stage 2: Component-function analysis*	*Stage 3: Systemic problems*	*Stage 4; Systemic instrument goals*	*Stage 5: Design systemic instruments*
Actors • Project champions • Student involvement • Other departments (same university) • Other SA universities. • International universities. • Community members. • Government. • Businesses. • NGO's/ Non-for-profit organisations. . **Interactions** • Nature of relationships (formal, informal). • Collaborative networks and partnerships. • Partner contributions (funding, strategic leadership, equipment, facilities, expert advice). • Mode of community interaction (e.g. cooperatives). **Institutions** • University policy that governs the inclusive innovation project.	**Entrepreneurial activity** • Project champion • Involvement • Experimentation • Entry	• **Actors:** Presence/ capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?	**Actors:** • Induce and stimulate the participation of several actors. • Create spaces where actor capabilities can be improved. **Interactions:** • Stimulate and induce interactions between diverse actors. • Block or address ties that are either too strong or too weak. **Institutions:** • Stimulate the presence of hard and soft institutions. • Do not allow institutions to be too weak.	**Actors** • Focus groups; feedback sessions; workshops. • New types of partnerships. • Interactive actor involvement techniques. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions. **Interactions** • Innovation platforms; collaborative research programmes; conferences. • Stimulate demand articulation. • Bridging institutions (community liaison, local NGO). • Management of interfaces. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions. **Institutions** • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Programme assessment and monitoring. • Awareness campaigns; information campaigns. • Stimulate demand articulation: bottom-up knowledge creation; co-creation models; training, information and education sessions.
	Knowledge development • Sources and process of knowledge development • Knowledge infrastructure • Research collaboration	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?		
	Knowledge dissemination • Focus of dissemination • Capacity for diffusion • Method for diffusion	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?		
	Guidance of search • Targets • Recognised constraints • Belief in growth potential	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity?		

Analytical framework

• University incentive and reward systems for the project. • Other external support systems. • Intellectual property and models of ownership. • Arranging the UTIID projects and community engagement (e.g. NGO's, cooperatives, community, church). **Infrastructure** • Physical infrastructure. • Knowledge infrastructure.		• **Infrastructure:** Presence/Quality?	**Infrastructure:** • Stimulate and induce the presence of different infrastructures. • Make sure that the infrastructure is of acceptable quality.	• Stimulate strategy and vision development: bottom-up knowledge creation; co-creation models; training, information and education sessions. • Memorandum/agreement; obligations; articulation of commitment. • Focus groups; feedback sessions. **Infrastructure** • Awareness campaigns; information campaigns. • Knowledge and financial infrastructure needs to be put in place in order to construct a business model. • Provide infrastructure for strategic intelligence. • Access to capital through grants/loans/funding; various business models. • Grants/ loans/funding to incentivise UTIID project and to employ full time staff members.
	Market formation • Institutional infrastructure • Market-readiness	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?		
	Resource mobilisation • Access to capital • Innovation platform or stand-alone? • Public spending	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?		
	Creation of legitimacy • Group confidence • Commitment • Partnership forming • Business plan assessment	• **Actors:** Presence/ • capabilities? • **Interactions:** Presence/Quality • **Institutions:** Presence/Capacity? • **Infrastructure:** Presence/Quality?		

CHAPTER 6 CASE STUDIES

Phase 1: Problem Statement & Systematic Review	Phase 2: Framework	Phase 4: UTIID evaluation tool
	Phase 3: Case Studies	

The framework developed in Chapter 5 is aimed at assessing UTIID projects. It is thus necessary to determine whether the framework is indeed able to reach this aim. This chapter will start by introducing the 16 case studies in our sample to which the framework was applied. This is followed by an overview of the current state of monitoring and evaluation (M&E) in UTIID projects based on our sample and an input, output and outcome typology is constructed based on our interview results.

Next the component-function assessment is applied to 16 UTIID projects from four different universities in the Western Cape. This has a dual purpose, first to see if the component-function approach is applicable to the assessment of UTIID projects and secondly, by applying the approach to the 16 projects in our sample we gain a broad understanding of how these projects are structured and how they function in order to build a typology of systemic instruments that are specifically applicable to UTIID projects. This is useful as the knowledge gained from this exercise will be used to construct an evaluation tool in CHAPTER 7. The functional analysis aims to identify pressing areas in project functioning that need to be addressed and to provide recommendations on how to address these problem areas.

Chapter 6 intends to achieve the following:

- Evaluate monitoring and evaluation practices in current UTIID projects through in-depth case studies.
- Construct Input, Output and Outcome typologies based on the UTIID project case studies that can be used for diagnosis and technical advice in future UTIID projects.
- Validate the component-function approach (identified in Chapter 4) as an applicable approach for the evaluation of UTIID projects by applying it to case studies.

6.1 Introducing the UTIID projects

We started with a list of five projects identified during the pilot project and sourced 11 UTIID projects to get a total of 16 implemented innovations for our study. *Table 28* provides a brief overview of the 16 UTIID projects in our sample. We followed the case study methodology described in Section 2.2.3 on page 12 to select projects and collect data.

Table 28: UTIID Projects

Case studies

Project	Description	University
A1	Design and construction of structural interventions in rural communities in SA. So far they have built a roof-covered gathering space for a school and water platforms.	CPUT
A2	Incorporated service learning into a module that entails community mapping. The students and community participate in the mapping of the informal settlement. The community then re-blocks the community so that the government can implement services.	CPUT
B1	SU Department of Aquaculture developed small-scale trout farming process that provided opportunity for farm workers to start their own trout farms without the ownership of land being a primary prerequisite.	SU
B2	Point-of-use microfiltration system for production of clean water. The devices are cost effective and uses gravitational force instead of external energy sources for filtration.	SU
B3	Explore the use of technological support for school learners who require human readers during tests and examinations, in particular learners with reading disorders. The project replaced human readers with MP3 players that contained a pre-recording of the tests.	SU
B4	The development and implementation of a generic development platform that enables any individual to easily develop individual therapy software (tools) for autism spectrum disorders, without resorting to extensive software development.	SU
B5	The Research Centre is a collaborative research centre that consists of researchers from the university as well as co-researchers from the marginalised community. The centre executes several informal settlement upgrading projects.	SU
B6	This project explores alternative access to classroom teaching by exploring e-learning to promote inclusivity of students who have special learning needs that could be met by attending class “outside” of the physical classroom.	SU
B7	An intervention which seeks uses SU Telematics Division’s interactive satellite platform to provide supplementary support for learners in underperforming schools, especially in rural communities of SA.	SU
C1	This project focuses on the fishery sector. It is a mobile phone application that allows the fisher community to communicate and share data with scientists and vice versa.	UCT
C2	Developed affordable heart valves in order to treat rheumatic heart disease with heart-valve surgery.	UCT
C3	This project developed and implemented a device that detects a change in temperature within a shack and sets off a network alert to protect against fires.	UCT
C4	This project developed a mobile retinal camera to screen for diabetic vision impairment. It provides a cost-effective alternative to traditional methodologies.	UCT

C5	The design and construction of water platforms in a rural community in SA. These platforms provide cleaner, more efficient and safer water collection areas. The platforms are used for water collection and clothes washing.	UCT
D1	This project looks at healthcare communication. Sign support is mobile phone application that allows the pharmacist to "speak" to a deaf patient, where without assistive technology they would not be able to communicate with each other.	UWC
D2	The design and development of a business case and mesh network in a remote rural community as a cost-effective alternative to traditional mobile networks.	UWC

The following section will describe whether these projects are currently performing monitoring and evaluation and if so, to what extent.

6.2 Monitoring and evaluation

As discussed in the beginning of Chapter 1, this study builds upon a pilot study conducted by Grobbelaar *et al*. [17] with the emphasis of this new empirical study being the addition of a functional analysis as well as the measurement, and evaluation of socio-economic impacts brought about through UTIID projects. This section will show how the projects in our sample are currently monitoring and evaluating their socio-economic impact.

6.2.1 Monitoring and evaluation in UTIID projects

The research questions we set out to answer regarding the monitoring and evaluation of UTIID projects are:

1. Are projects being monitored and evaluated? To what extent?
2. Are there barriers that inhibit evaluation?

These questions were answered through data collected during the case study interviews, the data can be seen in Appendix C. In order to determine the extent to which these projects were monitoring and evaluating performance and outcome we made use of the evaluation model developed by Mouton [166] shown in Figure 10. This model divides an intervention into the four stages of its lifecycle and then shows the corresponding stage of comprehensive evaluation that should be conducted at each phase of the life cycle. We then classified each project in our sample according to its position in the intervention lifecycle in order to see if sufficient M&E was being conducted.

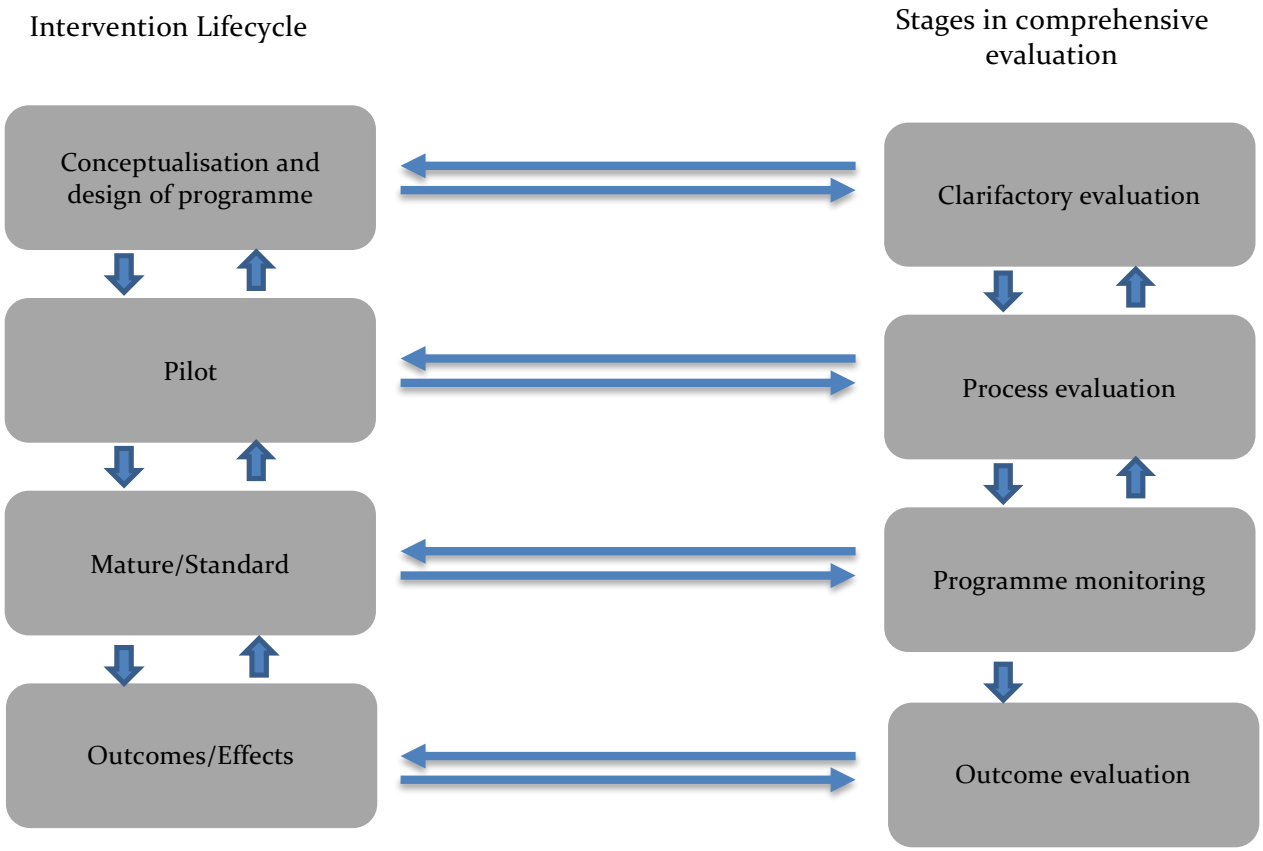


Figure 10: Evaluation model developed by Mouton [166]

Each of the stages of comprehensive evaluation in the evaluation model are described below.

- **Clarifactory evaluation** makes use of the logic model framework of evaluation in order to determine whether the intervention has clearly formulated goals, objectives, activities, expected outputs and expected outcomes.
- **Process evaluation** focuses on the delivery and implementation of interventions asking questions such as: Are the activities being properly performed? How are the activities received and accepted by the target group? Is implementation as scheduled?
- **Programme monitoring** evaluates the quality and continuous achievement of the outputs and outcomes of the intervention.
- **Outcome evaluation** aims to determine whether the intervention has achieved the expected outputs and outcomes, and whether this has had a positive effect on the target group.

6.2.1.1 RESULTS

Table 29 shows in which phase of their life cycle each project is as well as the stage of evaluation it is conducting. The shaded areas show which stage of evaluation should be conducted for each phase of the intervention life cycle. From the results in Table 29 we can see that projects in our sample that are still within the first three phases of their life cycle conduct sufficient monitoring and evaluation of outcomes. It can however be observed that the projects that are in the final phase of their lifecycle (A1, A2, B4 and C5), meaning they have been successfully executed and achieved the desired objective, are either not performing sufficient evaluations or not performing evaluations at all. This confirms our initial problem statement that states that there exists a gap regarding the evaluation of UTIID project outcomes.

Table 29: Degree of evaluation conducted

Project ID	***Intervention life cycle***	***Clarifactory evaluation***	***Process evaluation***	***Programme monitoring***	***Outcome evaluation***
D1	Conceptualisation and design of programme	x			
B2	Pilot		x		
B3	Pilot		x		
B6	Pilot		x		
C1	Pilot		x		
C2	Pilot		x		
B5	Mature/standard version of programme implemented			x	
B7	Mature/standard version of programme implemented			x	
C3	Mature/standard version of programme implemented			x	
C4	Mature/standard version of programme implemented			x	
D2	Mature/standard version of programme implemented		x		

A1	Intervention outcomes/effects		x		
A2	Intervention outcomes/effects		x		
B1	Intervention outcomes/effects				x
B4	Intervention outcomes/effects			x	
C5	Intervention outcomes/effects			x	

In order to start developing solutions and promote the need for outcome evaluations in UTIID projects we asked project leaders why they were not evaluating outcomes and whether there were any barriers to evaluation. The following section will discuss the challenges and barriers that were listed by the project leaders.

6.2.1.2 BARRIERS THAT INHIBIT OUTCOME EVALUATION

The results in Table 29 shows that four out of the five projects (A1, A2, B4 and C5), in our sample that are in the last phase of their life cycle stopped evaluating at the Process evaluating and Programme monitoring stages of evaluation. We found that many of the projects in our sample are executed in order to test an innovation and once the concept has been 'proven', the project team stops being involved in the intervention. During the interviews the project leaders were asked why they do not return to the communities to conduct outcome evaluations. The project leaders listed several barriers, and these have been categorised into four different categories namely, institutional factors, human factors, contextual factors and evaluation factors. Table 30 below summarises the results of these discussions.

Table 30: Barriers to outcome evaluation

Category	***Examples from interviews***
Institutional factors	• Lack of incentives (university incentivises publications and research outputs).

Human factors	• Lack of skills to perform such evaluations
	• Team turnover (students)
	• Limited resources
	  ◦ Time
	  ◦ Human infrastructure
	  ◦ Funding

Contextual factors	• Political situations within communities could inhibit return to a community.

Evaluation factors	• Insufficient resources to collect data • Inappropriate methods/instruments • Lack of participatory evaluation (community does not continue in their own).

It is of value to start identifying these barriers so that we can know what needs to be done to promote outcome evaluation in UTIID projects. With reference to Table 30 we found that the biggest challenge is that there is no incentive for conducting evaluations. University researchers are incentivised to produce research outputs and publications; therefore, once a project has been successfully implemented and achieved the desired objectives, the researchers do not have the capacity to continue monitoring and evaluating these projects as it falls outside of their 'job description'. Due to this there is also limited to no resources available to perform outcome evaluations.

In the next section, Input, Output and Outcome typologies were constructed based on the UTIID project case studies. These typologies can be used for diagnosis and technical advice in future UTIID projects.

6.3 Input, output and outcome typology

In order to construct a typology describing the inputs, outputs and outcomes of UTIID projects, we followed the grounded theory approach. Interview transcripts were analysed and coded to identify inputs, outputs and outcomes of UTIID projects in our sample. Next we followed an iterative process of synthesizing concepts into a typology. A typology can be defined as a conceptual classification scheme [167]. Such a scheme does not have to be exhaustive within its empirical frame of reference. The term typology represents both the process of developing types which aim to bring order to a complex system and assist the analysis of such a system, and the different sets of types that are defined from this process. The process of building up 'types' in a typology results from grouping activity units based on their functioning and features. A typology aims to establish a range of 'types' that simplifies reality while at the same time making distinctions between the different 'types' that are to be studied and analysed. A typology can be used for diagnosis and to derive technical advice [167].

Before the results are presented, the definitions of what is meant by inputs, outputs and outcomes in this study are listed below:

- Inputs: The resources required to perform activities/functions.
- Outputs: The measurable and tangible results of the activities conducted.
- Outcomes: "*an effect on, change or benefit to the economy, society, culture, public policy or service, health, the environment or quality of life…"* [168].

The inputs, outputs and outcomes of each UTIID project can be viewed in Appendix E. The input and output typology was constructed using interview data as well as suggestions from the pilot project conducted by Grobbelaar *et al*. [18]

There are several beneficiaries involved in the UTIID projects, each with their own interests for participating, own set of inputs, expected outputs and outcomes. We believe that it is of value to look at the specific beneficiaries separately when evaluating UTIID projects as this will enable us to identify failures not only in terms of functionality but also in terms of the actor responsible for the failure.

We have identified four main beneficiaries from our sample of UTIID projects. These are (1) the marginalised community; (2) the academics/researchers; (3) university students, and (4) the university itself. Table 31 provides a brief definition of what is meant by each of the above mentioned beneficiary groups.

Table 31: Beneficiaries of UTIID projects

Beneficiary group	***Definition***
Marginalised community	The target group of the UTIID project.
Academic/Researcher	The university staff members or students that drive the UTIID project i.e. the project champion.
Students	These are students that are involved in the project either because: • They are participating in order to receive a degree such as a PhD or Masters. • The project forms part of their syllabus (service learning).
University	The university (institution).

6.3.1 INPUT AND OUTPUT TYPOLOGIES

Table 32 and Table 33 show the input and output typologies. These were constructed by iteratively synthesising the inputs and outputs of each beneficiary group.

Table 32: UTIID projects input typology

Beneficiaries	***Inputs Typology***
Marginalised Community	• Human Infrastructure • Social knowledge

	• Skills/Capabilities • Pre-established relationship with community • Design (inputs)
Academics/ *Researchers*	• Skills/Capabilities • Strategic leadership • Technical knowledge • Expert advice • Design • Design (inputs) • Human Infrastructure • Business knowledge
Students	• Skills/Capabilities • Technical knowledge • Design • Design (inputs) • Human infrastructure
University	• Equipment • Facilities • Funding • Institutional infrastructure • Business knowledge

Table 33: UTIID projects output typology

Beneficiaries	***Outputs Typology***
Marginalised Community	• Access to information • Alternative modes of education (more inclusive) • Built interventions • Clean water and sanitation • Designs • Electronic communication • Employment opportunities • Improved nutritional status • Inclusive medical treatment • Increased income per capita • More practical layout of settlement • Skills/ Capabilities
Academics/ *Researchers*	• Awards • Conference presentations • Masters • PhD's • Publications
Students	• Conference presentations • Masters • PhD's • Publications

	• Practical experience • Course credits
University	• Awards • Conference presentations • Masters • PhD's • Publications • Good reputation • CSR

6.3.2 OUTCOME TYPOLOGY

Construction of the outcome typology was conducted using both the interview data as well as guidance from literature. The outcome typology serves as a classification typology that can be used to determine the type of value that is being created for the marginalised community. This is expressed in terms of 'capitals' and 'market' and 'non-market' related outcomes. These concepts are described below.

A general classification of socio-economic impact (referred to as 'outcomes' in our study) found in literature is 'market' and 'non-market' outcomes. Market-based outcomes can be measured in terms of market related outputs such as increased income or employment created in a marginalised community. Non-market-based outcomes cannot be measured in monetary terms, rather these are rooted in social interactions and networks [169]. The market vs. non-market classification is represented in the columns of Table 34.

The 'capitals' listed in the rows of Table 34 are from Cheryl [170]. Capital is defined as any type of resource that is capable of producing other resources and when a resource is invested, it becomes a capital. Literature lists seven different types of capitals that can be used to determine how well community resources are being used. For the purpose of outcome evaluation, we will focus on which capitals are developed as a result of the outputs of UTIID projects, and due to the specific application to UTIID projects we have also made an addition to the types of capital. Below follows a brief description of each community capital [170]:

- Built capital: Infrastructure and tangible buildings in a community.
- Cultural capital: Traditions and shared identity, ethnicity.
- Human capital: Human skills, capabilities and knowledge.
- Social capital: Connections within communities, networks and the sense of belonging.
- Political capital: The ability to voice needs and have influence to achieve certain aims.
- Financial capital: Money.
- Academic capital: All academic relates outcomes.
- Business capital: The establishment of spin-out businesses/corporations.

Table 34: UTIID projects outcome typology

	Market	*Non-market*
Built capital	• Water and sanitation • Buildings • Machinery • Roads • Electronic communications	• Contribution to regional governance and planning • Cohesive and secure environments • Improved health care facilities/treatment
Cultural capitals		• Language • Festivals • Shared identity • Greater cultural tolerance and enhanced democracy
Human capital	• Jobs created • Employability of graduated university students	• Investments in people: Learning, education, experiences, leadership development • Improved health • Improved safety • Faster and wider diffusion of new knowledge
Social capital	• Corporate Social Responsibility (CSR)	• Sense of belonging • Trust • Networks • Community capacity building
Political capital		• The ability to influence the distribution of resources. • Voice • Power • Connections
Financial capital	• Funding • Grants and Loans • Investments • Higher earnings/cost savings	
Academic capital	• Publications • Conference presentations • R&D partnerships • Degrees • Research • Invention	• Faster and wider diffusion of new knowledge • Networks
Business capital	• Established businesses/corporations	

6.3.3 GOAL OF INPUT, OUTPUT AND OUTCOME TYPOLOGIES

These typologies serve as the first building steps towards an evaluation tool. A typology can be used for diagnosis or to provide technical advice. These typologies can then be compared to the inputs, outputs and

outcomes of a project to identify areas that require attention. It must however be emphasised that not all of the inputs, outputs and outcomes in the typology are required for every project. Equipment for example would not be required for a service innovation. The typology however serves as a guide that can help the project champion see what general inputs, outputs and outcomes are and from that he/she can discern whether some are missing from the project.

In the following section, the analytical framework described in Chapter 5 is applied to 16 case studies in order to test its applicability as an approach to evaluate UTIID projects.

6.4 Component-Function analysis

The framework described in Chapter 5 was applied to the 16 UTIID projects included in our sample. The analysis will follow the steps described shown Figure 11. The component assessment was thus conducted to identify and assess the actors, relations, innovation, infrastructure and institutions present in each project. This is followed by a descriptive functional assessment during which systemic problems are identified and systemic instruments are designed to address these problems.

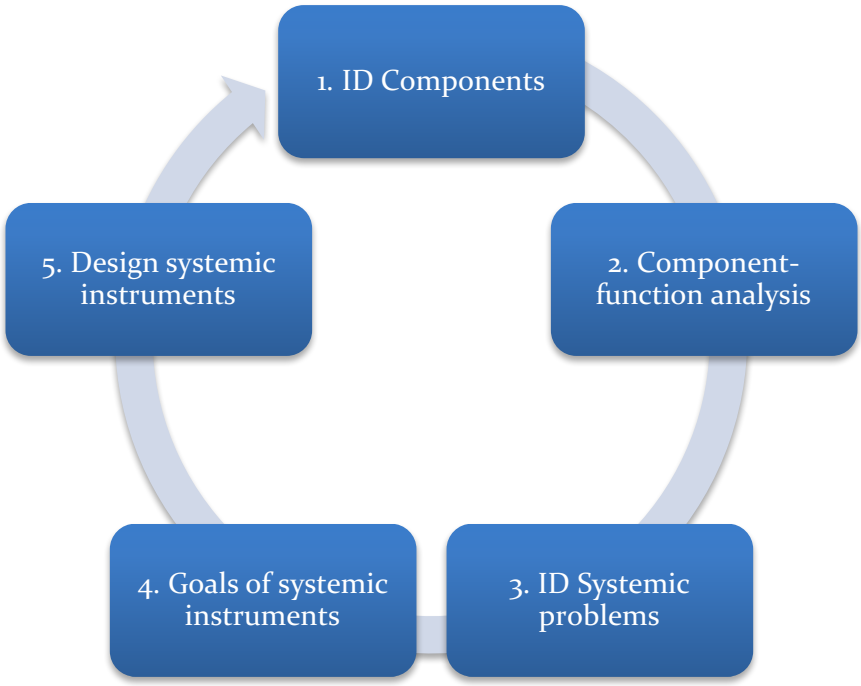


Figure 11: Framework for the analysis of innovation systems [43]

6.4.1 STAGE 1: IDENTIFY COMPONENTS

System performance is best analysed by means of a combined component-function based assessment. It is important to identify the structural elements within the UTIID projects before the functional assessment as a function can only be improved by changing one or more of the structural elements of the UTIID projects. This sub-section will provide an overview of the component assessment of the 16 UTIID projects in our sample.

6.4.1.1 ACTORS AND RELATIONS

There are a range of different actors involved in each UTIID project. Using the framework developed in Chapter 5 we researched the actors involved and their contributions to the innovation. The main focus of relations was on the nature of engagement and partnerships as enablers, the level to which the community was 'included' and the mechanisms of community interaction [17].

Different actors involved

All of the projects have a champion that drives the project. In accordance with Grobbelaar *et a*l.[18], we also found that the project champion is usually and academic who is committed to the promotion of equality and development. Students were involved either as researchers conducting their final year theses, Master or PhD theses. Two of the projects from our sample A1 and A2, were integrated into the course syllabus. In these cases, the students were involved in the design, development and implementation of the inclusive innovation interventions. In two (B4, C3) of the projects the students were the actual inventors of the projects and fulfilled the role of project champion under the supervision of a faculty member.

There was a wide range of actors involved in the UTIID projects. As found in the pilot study these actors can generally be divided into one of the following categories: project champions, student involvement, other departments (same university), other SA universities, international universities, community members, government, businesses and NGO's/ non-for-profit organisations. Figure 12 displays the range of actors present in each of the UTIID projects.

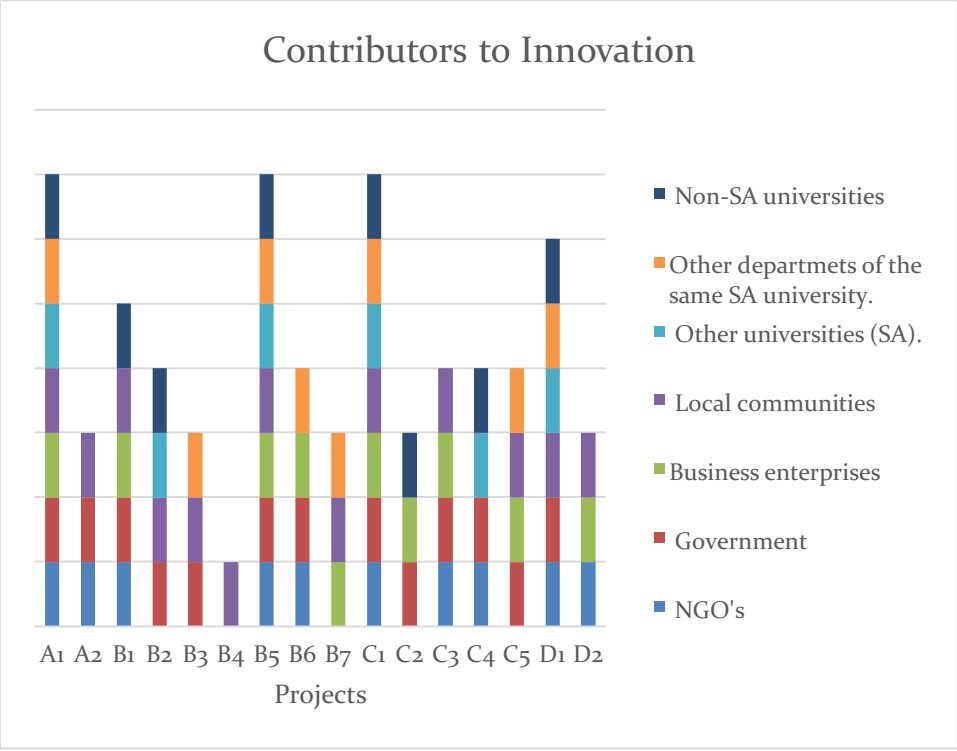


Figure 12: Range of actors contributing to each UTIID project

Partner contributions

All of the UTIID projects in our sample are made up of both formal and informal partnerships between the project team (university) and other partners. These partnerships (shown in Figure 12) serve as enablers by contributing in different ways. Table 35 shows which contributions are made and highlights the contributions that are mostly made by each specific partner in our sample. The results show that other departments from the same university of the UTIID project mostly participate in co-research, i.e. the departments work together to enable the project. Other SA and international universities participate by sharing knowledge. The local (marginalised) communities allow the projects to be implemented in their communities and then provide feedback on the project. Most of the contributions from government, businesses and NGO's are made in terms of funding. All of the projects are dependent upon funding from the university or other sources. Another very important contribution from NGO's and local municipalities are pre-established relationships with the marginalised community members. In several of the projects in our sample (A1, B2, C1, D1, D2) a member from the local NGO/municipality would serve as a community liaison that would communicate with the community on behalf of the project team. Three of these projects listed working through an NGO that has a pre-established relationship as a critical success factor as it decreases the time required to gain trust and increases the chance of acceptance of the innovation.

Table 35: Actor contributions

	Other departments	*Other universities (SA)*	*International universities*	*Local communities*	*Government*	*Businesses*	*NGO's*
Funding	1	0	1	1	8	5	5
Skills/Capabilities	3	1	2	2	1	1	3
Knowledge sharing	0	5	5	1	0	0	4
Expert advice	1	0	0	0	0	3	2
Strategic leadership	2	0	0	1	0	1	3
Human infrastructure	0	0	2	3	1	0	3
Facilities	0	0	0	0	2	1	1
Equipment	0	0	1	0	1	2	0
Co-research	6	4	4	1	0	0	0
Institutional infrastructure	1	0	0	0	2	1	0
Feedback	0	0	0	11	2	0	0

Degree of community involvement

One of the main focus points under 'Relations' is the level of inclusiveness and the nature of engagement with the marginalised community. As described in Figure 9, we divided the degree of community involvement into three categories based on whether they were included in the design, development or implementation phase of the innovation. Table 36 portrays the degree of community involvement present at each project in our sample.

It is evident that the community is mostly involved with the implementation phase of the innovation which implies that they accept and use the innovation. The community was involved in the design process of only three projects, meaning that the 'direct' contribution of the communities to the innovations is very small.

Considering the results shown in Table 36, it is clear to see that all the projects have provided an innovation that was implemented and 'consumed' by the marginalised communities. Only three of the projects included the community in the Design phase and six in the Development phase. Considering the definition of innovation for inclusive development: *" to create or enhance opportunities to improve the wellbeing of those at the BoP"* [6] along with the notion that inclusive innovations aim to include the marginalised community members not only as consumers but also as business partners who are included in the innovation process, so that, as solutions are conceptualised and developed and goods are manufactured, they can benefit economically from such innovations, it is evident that the UTIID projects in our sample need to find ways to involve the community members in the earlier phases of the innovation process.

Table 36: Level of inclusiveness

Projects	*Design*	*Development*	*Implementation*
A1			✓
A2	✓	✓	✓
B1			✓
B2		✓	✓
B3			✓
B4		✓	✓
B5	✓	✓	✓
B6			✓
B7			✓
C1			✓
C2			✓
C3			✓
C4			✓
C5		✓	✓
D1	✓		✓
D2		✓	✓

6.4.1.2 INNOVATION

The types of innovation were classified as either product/service, process or a combination of the two. Figure 13 summarises the types of innovations observed in the UTIID projects. In Figure 14 we classified all of the innovations in our sample based on their degree of newness vs. impact. Most of the innovations are incremental in terms of newness, consisting of minor changes to already existing technologies. The impact of these innovations are however mostly disruptive as they are completely new to the context in which they are

implemented, creating new value by meeting demand-driven needs with simpler and less expensive products and services.

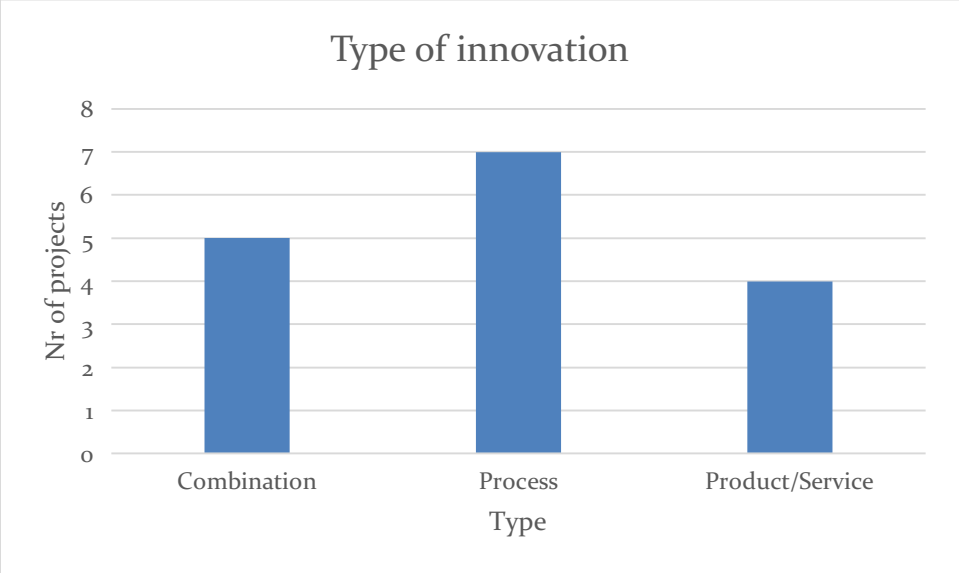


Figure 13: Type of innovation in UTIID projects

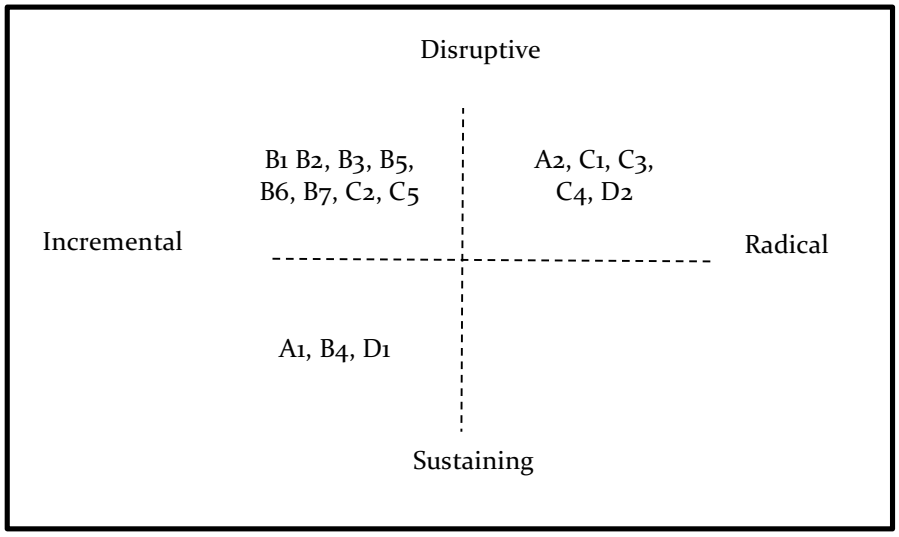


Figure 14: Newness vs. impact: innovation [149].

Strategies for the innovation process

The strategy of the UTIID projects were classified as either for profit, hybrid or non-for-profit. Here 'Hybrid' refers to projects that are using various business models to start moving from non-for-profit to for-profit, but are still dependant on funding. As can be seen in Table 37, most of the projects were classified as non-for-profit/ developmental. The project objectives, and therefore dominant university mission behind driving these

projects (the project champion's main rationale for conducting the project), were classified as either student education, research or community development. In most cases, we found it is either education/ research in combination with community development.

Table 37: Strategies for the innovation process

	Student Education	***Community Development***	***Research***
For profit			
Hybrid		B1, C1, C2, C3, D2	B2
Non-profit	A1, A2, B6, C7	A1, A2, B3, B5, B7, C4, C5, D1	A1, A2, B4, B5

6.4.1.3 INFRASTRUCTURE AND INSTITUTIONS

Infrastructural components are important for the successful development and implementation of innovations. As suggested by the framework we focused on knowledge infrastructure, financial infrastructure and management infrastructure. Institutions refer to cultures, norms and regulations that influence both the actors in the system and the system as a whole.

Infrastructure

A key function of the university representatives in all of the projects in our sample was their knowledge contributions. They were the actors responsible for the technical know-how and expertise required to develop the technological innovations. Absorptive capacity is a term used to describe the ability of innovation actors to integrate and utilise external knowledge. The absorptive capacity of the UTIID project is of critical importance as it is what enables the project team to identify and exploit the value of the specific technological innovation. For the case of a UTIID project it is determined based on the prior knowledge that the project team has [17], and in order to analyse this we focused on whether projects are stand-alone or embedded within innovation platforms and learning spaces that provide knowledge, physical and financial infrastructure. We observed that the existence of incubators and other innovation platforms at universities, creates ties between projects, facilitating the diffusion of knowledge. We have observed a lack of institutionalisation in our sample. Only 5 out of the 16 projects in our sample are embedded within an innovation platform. Such a platform is ideal as it provides institutional backup that promotes sustainability. If the project driver leaves, such a platform could enable the continuity of the project. It also provides a basis where knowledge on what works and what doesn't can be transferred to new projects or students that become part of existing projects, therefore increasing the absorptive capacity of the UTIID project [17].

All of the projects in our sample are dependent upon funding from the university or other sources. Five of the projects are hybrids (i.e. combination of developmental/non-for-profit and for-profit) and are aiming to become a for-profit project (i.e. self-sustainable), but none have reached that point yet. Figure 15 shows the sources of the UTIID projects' funding.

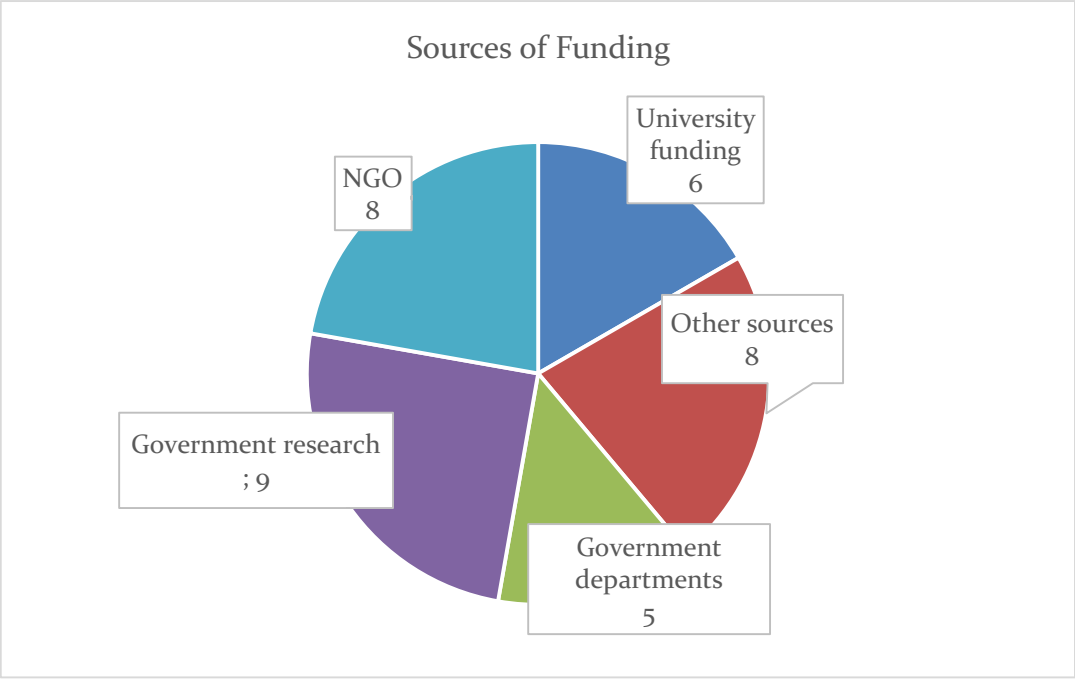


Figure 15: Sources of UTIID projects' funding

Intellectual property

There exists a conflict between the social development objective of providing open access to all and the commercial and economic notion of obtaining select rights to certain resources such as intellectual property (IP) rights [17]. This does not suggest that the developmental/open source approach is superior in terms of innovation for inclusive development and literature about this specific focus area is very limited and more research needs to be done to determine the advantages of both these approaches [17]. We observed both cases within our sample. Some projects such as C1 (UCT) and A2 (CPUT) made their intellectual property available on an open source basis where anyone has access to it. Project C1 (UCT) was given free access to the Salesforce© platform on which the application software was developed and project B6 (SU) was entirely facilitated on an open source live streaming service provided by Google called Hangouts on Air. It is evident that technological innovation could be developed because resources such as knowledge, software and platforms were freely shared. In these projects social impact was brought about by the use of the innovations themselves, but by also making these innovations freely available to the public, their design and development could also result in social impact. There were also projects in which IP rights played a critical role, especially in terms of commercialisation. With the assistance and legal guidance of UCT's Research Contracts and Intellectual Property Services, Project C3 (UCT) obtained copy rights for their software codes and UCT owns the technology patent. This project developed into a spin off company that now develops and sells/provides the fire detection devices. This innovation has social impact once it has been implemented into and used by a community.

Social capital and mechanisms of community engagement

We discovered two trends in the way that the UTIID projects in our sample engaged with the marginalised community. In most of the projects, the project champions were the ones who developed a relationship with the community and were able to inspire and gain the trust and commitment of the community. As discussed in Section 6.4, the project champions were mostly members of the university staff. The project champions play an important role in terms of project sustainability, especially in cases of service learning where different students participate in the project each year. Here the project champion ensures that the projects are executed and that the absorptive capacity increases. The second mechanism used for community engagement was the use of intermediaries or community liaisons to approach the community. In these cases, the UTIID project would approach a NGO in the community or the local municipality as they already had an established relationship with the specific community. This mechanism reduced the time it took to gain trust and increased the adoption rate of the innovation.

6.4.2 STAGE 2: COMPONENT-FUNCTION ANALYSIS

The following section summarises the findings of the functional assessment. It is the result of interpreting statements made in the interviews and allocating them to specific functions.

6.4.2.1 F1: ENTREPRENEURIAL ACTIVITIES

Entrepreneurs are the key actors that transforms potential into action [40]. In the context of UTIID's the project champions fulfil the role of the 'entrepreneur'.

Community involvement

One measure used in literature to analyse Entrepreneurial activity is to observe whether new entrepreneurs are developed. There is a very big gap in UTIID projects when it comes to involving the marginalised communities in the innovation process. Only five of the projects (A2, B1, B5, C1, D2) were successful in actually empowering members from the marginalised communities to become entrepreneurs that are capable of transforming potential into action. Institutions need to be put in place to ensure that knowledge is developed (F2) and successfully disseminated (F3) to marginalised community members in order to improve entrepreneurial activity (F1).

Experimentation

Many interview participants concurred that the UTIID projects were greatly dependent on funding for experiments to be conducted. Since this study focuses on technology-based innovations, there are high costs involved in taking the innovation from the "laboratory level" to the field. Despite the challenges regarding functions, all of the projects did perform experiments and launch pilot projects.

6.4.2.2 F2: KNOWLEDGE DEVELOPMENT

Knowledge is developed through the process of learning. In projects A1 and A2 (UCT) where the UTIID projects are integrated in the service learning program of the specific university departments, a process of mutual learning was developed. This interaction was beneficial to both the university departments and the marginalised communities as the students could gain practical experience in the field and the communities were equipped through training, new skills and knowledge. The UTIID project teams are the main sources of codified knowledge such as the technical know-how of the technology-based innovations. Tacit knowledge is developed through interaction between the UTIID project teams and the marginalised community.

For the UTIID projects that followed an "action research" approach the UTIID project teams are the main sources of codified knowledge, but the community becomes involved in the research process, by becoming actual researchers (A1, B5, C1) or participating in experiments/pilot projects. Codified knowledge is then transferred to the marginalised community through research or training and workshops, equipping them with research skills and the technical know-how of the innovation itself.

Several of the UTIID projects followed a "community-based research" approach where the project team conducts research and develops the innovation and the marginalised community serves as a site where the research can be conducted. The UTIID projects are the sources of codified knowledge and develop tacit knowledge through interaction with, and feedback from the community members. The knowledge developed by the community is relatively limited to the codified knowledge presented during training or instructions of use.

Knowledge and learning play a vital role in innovation for inclusive development [40]. As specified in the framework developed in the pilot study [17], we considered the following aspects when analysing 'knowledge and learning': the role of different actors; mechanisms used to develop knowledge; knowledge types and forms, as well as management strategies.

Actor roles in knowledge and learning processes

The UTIID project teams are the main actors in knowledge development, transmission and use. Developmental problems stem from the failure to expand and integrate "distributed knowledge" [171]. Such objectives can only be met through a learning process. Learning occurs when (1) an actor's capabilities are increased and (2) when practical problems are solved by the integration of various actor capabilities. In the first case it is the role of both the UTIID project and the marginalised community to develop new capabilities by means of learning. In the second case the actors who participate in the process of developing innovative solutions learn "by interacting" with the marginalised communities. These actors' capabilities are enhanced and their ability to cooperate and co-create with other actors are increased. These spaces where learning takes place are called "interactive learning spaces" [171].

Knowledge types, forms and management

The types of knowledge transferred were divided into three categories. Much of the knowledge transferred was the technical "know-how" of the innovation itself [17]. This transfer empowers community members in their role of co-designer, co-developer and consumer and helps engage communities in interactive learning trajectories. The first type of knowledge transfer is therefore, 'technical knowledge'. The second category is 'social knowledge'. According to several project leaders the understanding of social and cultural context was vital for the inclusive innovation process. Several projects started off by hosting focus groups within the community in order to gain this 'social knowledge'. This is especially important in a country such as South Africa that consist of many different cultures and ethnic tribes. Two of the projects, B2 (SU) and D2 (UWC) implemented within rural communities with cultural leadership hierarchies report that it is critical to build relationships and trust with the community leaders before trying to collaboratively implement innovations. This finding is supported by Swee [172], who reported that the development of a collaborative culture is dependent on a high level of trust. The third type of knowledge transferred in the projects reviewed is 'business knowledge'. This type of knowledge was transferred when community members were trained in the management of the innovation, or if this type of tacit knowledge was transferred by means of interaction. For example, project B2 (SU) entailed a compulsory technical and business training program for the community members. They were taught basic business skills such as budgeting and advertising. Figure 16 shows the distribution of types of knowledge transferred. Some projects entail the transfer of more than one type of knowledge and therefore the values in each category of Figure 16 show the amount of projects that transfers that type of knowledge out of the total 16 projects.

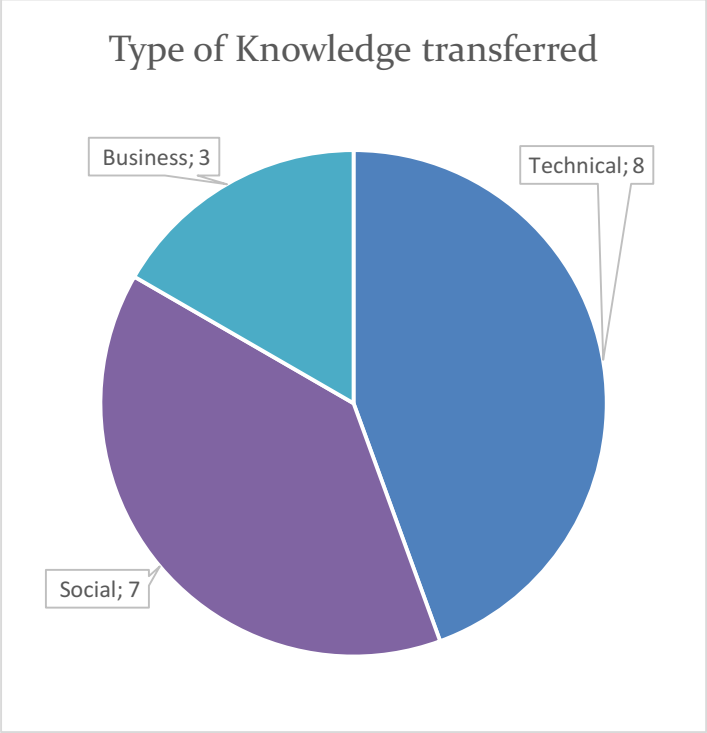


Figure 16: Distribution of the type of knowledge transferred

The form of knowledge transfer was also considered. The innovation processes of the projects reviewed were either top-down or bottom-up/collaborative. According to Andersen [173] the bottom-up approach can be described as the use of available resources, both material and nonmaterial, to craft efficient solutions to problems and challenges. Six of the projects in our sample used a bottom-up approach. The top-down approach implies that the 'know-how' and 'know-what' was transferred from the external project members to the marginalised community members, and the innovation itself is an initiative from the external project members. Regarding the transfer of technical and business knowledge we found a very top-down approach to knowledge development present in nine of the projects.

An excellent example of a bottom-up/collaborative approach from our sample, project C7 (UCT), entailed that students from UCT design water platforms and then actually go build them in the communities. During the 2013 construction they trained community members to make their own low-cost bricks using an innovative design containing glass bottles. A community member who use to work in construction taught the students how to mix cement and lay the bricks.

Mechanisms of knowledge development

Knowledge development can only be achieved through the process of learning [171]. When analysing the types of learning that took place in each UTTID projects, we used the three categories described by Foster & Heeks [38]: "learning-by-doing", "learning-by-interacting" and "learning-by-using". As the results show that the marginalised communities are mostly included in the implementation phase of the innovation process (Table

36), it is no surprise that most learning occurs while the community members make use of the innovation. Figure 17 displays the number of UTIID projects in which each of the types of learning takes place.

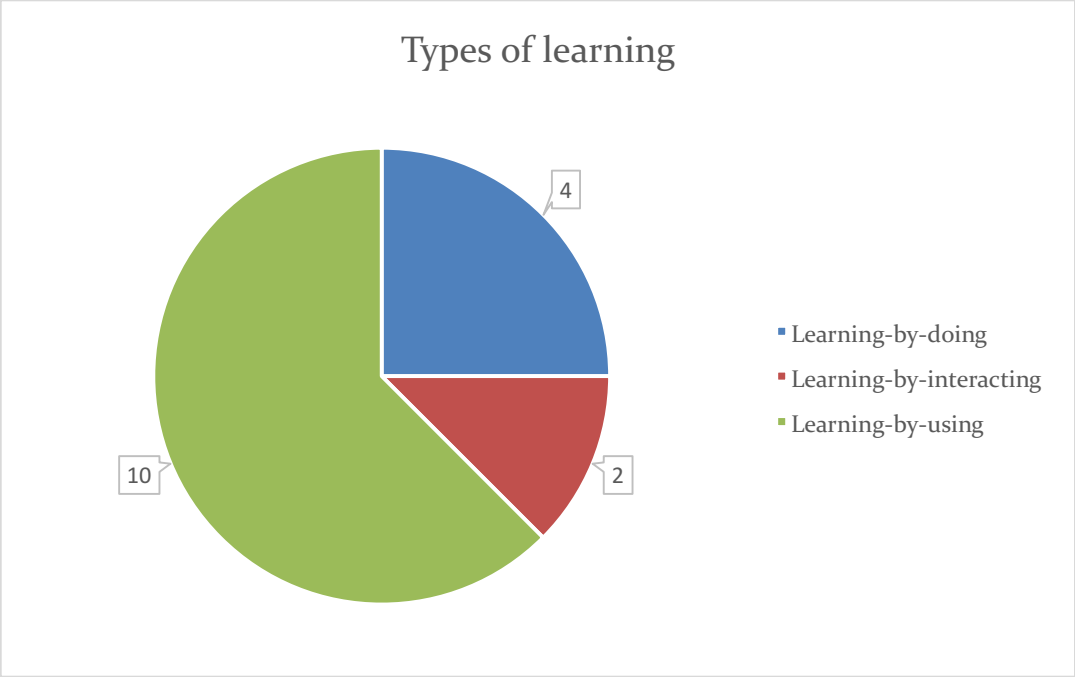


Figure 17: Types of learning used by the UTIID projects to transfer knowledge to the marginalised group

6.4.2.3 F3: KNOWLEDGE DISSEMINATION

We observed a very top-down approach in knowledge development, which does not necessarily meet the needs of the users. There were very few projects in our sample with structured methods for diffusion. Project B1 (SU) was the only project in which the community members had to attend a formal training workshop in which codified technical and business knowledge was transferred. Several projects (B2, B3, B4, B7, C3) disseminated knowledge by means of interaction with the community members and demonstrations of how to use or apply the innovation.

However, it is evident that the interaction between various actors from different backgrounds can result in fruitful considerations and creative solutions for societal challenges. These interactions also highlight modifications that need to be made to innovations to better meet the needs of the marginalised communities. For example, the innovative product used in project C3 (UCT) was developed by a final year engineering student, who then decided to continue the project and actually implement the product. After a pilot phase, the student facilitated a feedback session with the individuals who used the device and found that several modifications would have to be made to the original design for it to be effective.

6.4.2.4 F4: GUIDANCE OF SEARCH

The targets set by the UTIID projects are dependent on the main university mission that drives the project. This can be either community engagement, research or teaching and learning. In 1997, the post-apartheid reconstruction of the SA Higher Education system required that community engagement should become one of the core responsibilities of higher education, alongside research, teaching and learning [14]. This prescribed requirement induced universities to start participating in community engagement through several different channels, UTIID projects being one of these channels.

The UTIID projects in our sample that are used for service learning aim to provide the students with practical training by means of alternative education that is not arbitrary i.e. contributes to social and economic development. The targets of research driven UTIID projects in our sample are to conduct 'experiments' and testing with the community or the community serves as a site where the 'experiments' and testing can take place.

We found that most projects are stand-alone projects started by individual academic staff members who serve as the project champions. There are no structural or formal institutions in place to encourage the formation of innovation platforms at the universities in our sample. The platforms that do exist were formed due to collaboration between individual researchers.

Recognised constraints

There are several factors that constrain innovation for inclusive development. We identified the constraints experienced by the UTIID projects in our sample in order to map patterns and find ways to increase the benefit gained form interaction between universities and marginalised communities. The recognised constraints were:

- Unsustainable funding.
- Time constraints: service learning projects' time-lines are constrained by the student syllabus and term dates.
- Vandalism of installed architectural innovations.
- The development of appropriately targeted training material given the education level of the marginalised community members.
- High turnover of staff in the projects. New workers each year, demanding new training.
- The political situation in SA.
- Lack of incentives to conduct such projects.
- Projects require full time staff in order to scale: university staff members are expected to lecture, do research and perform community engagement. In order for these projects to scale and become sustainable, it will require full time staff who can concentrate solely on the project.

6.4.2.5 F5: MARKET FORMATION

Market formation was assessed based on the presence of infrastructure required for the successful introduction of a technology-based innovation. We analysed the institutional, human, policy, financial and technological infrastructure.

Institutional infrastructure

The SA Higher Education act [14] enforced the development of institutional infrastructure which ensured the development of community engagement initiatives from every university department.

Human infrastructure

As a result of the technology-based focus of our study, technical knowledge and know-how was required for the development of innovations. Furthermore, specific skills were required to introduce and implement the innovations into the marginalised communities. As these innovations aim to be inclusive, they also require the involvement of the marginalised community members in some part of the innovation process.

As the innovations are university driven there was ample access to technical knowledge and know-how. The innovations were introduced to the community either by the project champion, students who were involved or an intermediary actor such as an NGO or community liaison.

Policy infrastructure

Several interviewees stated that there is a lack of policy infrastructures to incentivise UTIID projects. Participation in community engagement in an institutional prerequisite, but researchers are not recognised for such efforts. This was specifically found in projects that are not part of a service learning program or action research that would result in publications. The researchers are driven by an individual goal to use their knowledge to 'do good', but have to work on these projects outside of work hours as they have to meet university lecturing and research output requirements.

Financial infrastructure

There is a divide between projects in our sample that are fairly well funded and those who have very limited access to capital. Research-driven UTIID projects in our sample that are supported by government research funding agencies such as Technological Innovation Agency (TIA), Department of Science and Technology (DST) and National Research Fund (NRF) are generally the former, while service learning projects are the latter. Most of the interviewees did indicate that they receive some funding from the university, but that it was not necessarily a substantial amount and that it entailed a tedious application process.

The lack of access to capital is one of the greatest challenges that UTIID projects in our sample face. There are high initial costs involved in taking technological product innovations from the experimentation phase to implementation in the field. It is therefore important to identify mechanisms and approaches used by these

projects to gain financial resources. Apart from government research and university funding discussed earlier, we found that eight of the projects received funding from the NGO with which it was in partnership and eight received funding from other sources such as businesses or individual sponsors.

Technological infrastructure

The UTIID projects in our sample have ample access to the technological requirements of the development of the innovations as they have access to university facilities. The only limiting factor to the technological infrastructure is capital required to acquire additional equipment or technological requirements. In most cases however, the UTIID projects in our sample made use of technology that was available or used open source software for application development.

6.4.2.6 F6: RESOURCE MOBILISATION

Resource mobilisation describes all activities that provide support to the UTIID projects in terms of gaining access to human and financial resources.

Access to capital

As previously stated one of the greatest challenges faced by the UTIID projects in our sample is the lack of access to capital, especially the capital required to go from the development to the implementation of the innovation.

Public spending

Government research funding agencies provide funding for UTIID projects. The project leaders of projects B1 (SU), B2 (SU), B5 (SU), D1 (UWC) and D2 (UWC) listed the allocation of funds from research funding agencies such as DST, TIA and NRF as one of the critical factors that contributed to the success of their projects. Public spending thus plays a critical role in university driven innovation for inclusive development.

6.4.2.7 F7: CREATION OF LEGITIMACY

This function encompasses all activities that support the increased acceptance of a technology. The creation of legitimacy is a timely process that entails the creation of confidence and trust in the innovation. Knowledge needs to be developed in order to create expectations for the new technological innovation and in this way possibly create legitimacy.

Commitment and partnerships

As previously described in Section 6.4.1.1, each of the projects in our sample are driven by a project champion, and in accordance with the findings made by Kruss & Gastrauw [9], the leadership provided by and the commitment of this project champion is a key contribution to the success of UTIID projects.

In the assessment of current M&E in UTIID projects, we found that there is a lack of commitment post successful execution of the projects. Several barriers inhibiting further commitment were identified (Section 6.2.1). It is very challenging for UTIID projects to scale and become for-profit, self-sustaining businesses. Commitment can be improved through forming new partnerships and constructing incentives that will reward commitment.

The formation of partnerships is key to the creation of legitimacy. Partnerships serves as enablers that provide access to several resources such as capital and knowledge. Table 35: Actor contributions, on page 70, shows the different contributions from different actors in the projects. All of the projects in our sample are made up of formal and/or informal partnerships between the university, community and other actors. It can therefore be deduced that these projects have started the process of "creation of legitimacy".

Business plan assessment

As very few of the UTIID projects in our sample have actually moved beyond the initial implementation they do not have business plans. The five projects that have resulted in spin off companies are B1 (SU), B2 (SU), B5 (SU), C3 (UCT) and C5 (UWC). B1 formed a closed corporation with its own board of directors who were responsible for assessing the business plan. Projects B2 and B5 formed proprietary limited companies and was assisted by SU's technology transfer office, Innovus, to patent and commercialise the technology. In project B2, Innovus was very involved in terms of the management of the project as well, they appointed the project manager and was responsible for all administration. UCT's Research Contracts and Intellectual Property Services (RCIPS) helped project C3 with regards to its IP, commercialisation and business development. Project C5 gave the project over to be managed by a group of 10 community members appointed by the community. They are responsible for making decisions regarding the business plan and for assessing it, they registered the co-operative and are responsible for setting up and assessing the business plan.

6.4.3 STAGE 3-5: IDENTIFY SYSTEMIC PROBLEMS AND INSTRUMENTS

The aim of analysing system (functions) performance is to evaluate the functioning of the UTIID projects and to identify functions that are not being properly fulfilled. In the analysis explanatory reasons (systemic problems) for insufficient project functioning are identified and interventions are proposed to address these problems (systemic instruments).

6.4.3.1 FUNCTIONAL PERFORMANCE

The system functions of the UTIID projects were analysed using a methodology developed from a study conducted by Negro *et al.* [162] which was described in Section 5.3. This section will provide a summary of the functions within each UTIID project. The full analyses can be viewed in Appendix D. Table 38 shows the summarised results. The table is highlighted according to a colour scale which is shown below the table. Blue (A) is the highest value in each function and as the value decreases the colours move to the right of the colour scale. Red, (E) therefore represents the most pressing areas that need attention. In the analysis that follows

explanatory reasons (systemic problems) for the problem areas in each project is provided as well as suggestions (systemic instruments) of how to improve the components in order to improve project functioning.

Table 38: Summary of functional analysis of 16 UTIID projects

		UTIID Projects															
Function	***High score***	A1	A2	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	C5	D1	D2
F1: Entrepreneurial activity	3	0	3	2	2	0	0	3	1	0	1	1	2	2	1	2	2
F2: Knowledge development	2	0	2	1	1	1	1	2	1	1	2	0	1	0	0	1	2
F3: Knowledge dissemination	3	-1	3	1	-1	-1	-1	3	0	1	1	-1	-1	-1	0	3	3
F4: Guidance of search	3	1	3	3	2	1	1	3	2	3	3	2	2	3	2	3	3
F5: Market formation	7	2	6	5	5	0	2	7	4	7	6	7	2	7	0	-2	5
F6: Mobilisation of resources	2	-2	-1	0	2	-1	0	2	2	2	0	2	0	2	-2	0	2
F7: Creation of legitimacy	4	2	4	4	4	1	-2	3	3	4	4	2	4	4	4	4	4

Colour scale	A	B	C	D	E

6.4.3.2 SYSTEMIC PROBLEMS AND INSTRUMENTS

The systemic problems aim to explain the weak function performance. The systemic problems are related to the presence or attributes of system components[163]. Wieczorek and Hekkert [43] summarised a list of systemic problems from literature and conceptualised a set of systemic problem categories. These categories were used to identify systemic problems within the functions that are not being properly performed. These are all the functions that fall between B-E on the colour scale shown in Table 38, in other words, all the functions that are not dark blue. Next, systemic instruments are proposed to address these systemic problems. Each project was separately analysed to identify systemic problems and instruments, this can be viewed in Appendix D. Table 39 below provides a summary of all systemic problems identified per systemic function and proposes systemic instruments to overcome these problems.

Table 39: Systemic problem and instrument typology for UTIID projects.

Function	***Reason function weakness***	***Systemic problem***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	• Community absent in Design and Development phases.	**Actors:** Presence **Interactions:** Presence	• Induce and stimulate the participation of several actors. • Induce and stimulate interactions between diverse actors.	• Focus groups; feedback sessions; workshops. • Interactive actor involvement techniques. • New types of partnerships. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO).
	• Community unaware of the intervention in early phases.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
	• Extent of experimentation is limited.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Induce and stimulate the participation of several actors • Block or address ties that are either too strong or too weak. • Make sure that the infrastructure is of acceptable quality.	• Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions. • Evaluation methods and tools; forecasting; technology assessments; pilots.
F2: Knowledge development	• No/weak interaction between community and university project team.	**Actors:** Presence **Interactions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors.	• Focus groups; feedback sessions; workshops. • New types of partnerships. • Interactive actor involvement techniques. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions.

	• The Community is not involved in the research process.	**Interactions:** Presence **Institutions:** Presence	• Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns. • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions.
F3: Knowledge dissemination	• No space/opportunities created for knowledge transfer.	**Actors:** Capabilities **Interactions:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak.	• Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions.
	• Lack of meaningful interactions that could result in 'learning-by-interacting'.	**Interactions:** Quality	• Block or address ties that are either too strong or too weak.	• Bridging institutions (community liaison, local NGO). • Management of interfaces. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions.
	• Knowledge dissemination is top-down and not demand-driven; therefore, it is not 'inclusive'.	**Institutions:** Quality	• Do not allow institutions to be too weak.	• Stimulate demand articulation: bottom-up knowledge creation; co-creation models; training, information and education sessions.

	• Weak partnerships forming.	**Interactions:** Presence Quality	• Stimulate and induce interactions between diverse actors. • Block or address ties that are either too strong or too weak.	• Innovation platforms; collaborative research programmes; conferences. • Stimulate demand articulation: bottom-up knowledge creation; co-creation models; training, information and education sessions. • Bridging institutions (community liaison, local NGO). • Management of interfaces. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions.
F4: Guidance of search	• Vague targets for the use of technology, no M&E conducted beyond implementation.	**Institutions:** Quality **Infrastructure:** Quality	• Do not allow institutions to be too weak. • Make sure that the infrastructure is of acceptable quality.	• Stimulate strategy and vision development: bottom-up knowledge creation; co-creation models; training, information and education sessions. • Memorandum/agreement; obligations; articulation of commitment. • Provide infrastructure for strategic intelligence.
	• Marginalised community show some interest, but also vandalise the structures.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
	• Limited belief in growth potential.	**Infrastructure:** Quality **Institutions:** Presence	• Make sure that the infrastructure is of acceptable quality. • Stimulate the presence of hard and soft institutions.	• Trend studies; programme monitoring methods and tools; surveys; questionnaires. • Awareness campaigns; information campaigns.

	• Lack of awareness of the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
F5: Market formation	• No real incentive to promote market formation.	**Interactions:** Presence	• Block or address ties that are either too strong or too weak.	• Stimulate demand articulation: bottom-up knowledge creation; co-creation models; training, information and education sessions.
		Infrastructure: Quality	• Make sure that the infrastructure is of acceptable quality	• Grants/ loans/funding to incentivise UTIID projects.
	• Unsustainable source of funding.	**Infrastructure:** Presence	• Stimulate and induce the presence of different infrastructures.	• Access to capital through grants/loans/funding; various business models.
	• Lack of business plan development.	**Infrastructure:** Presence Quality	• Stimulate and induce the presence of different infrastructures. • Make sure that the infrastructure is of acceptable quality.	• Knowledge and financial infrastructure needs to be put in place in order to construct a business model. • Access to capital through grants/loans/funding; various business models.
	• Insufficient infrastructure (human, technological, financial)	**Infrastructure:** Presence Quality	• Stimulate and induce the presence of different infrastructures. • Make sure that the infrastructure is of acceptable quality.	• Grants/ loans/funding to incentivise UTIID project and to employ full time staff members.
	• Have to create a new market.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns to create demand (market) for these type of projects in marginalised communities.
F6: Mobilisation of resources	• Stand-alone project that does not form part of an innovation platform from which it can pool resources.	**Interactions:** Presence	• Stimulate and induce interactions between diverse actors.	• Innovation platforms; collaborative research programmes; conferences.

	• Unsustainable source of funding.	**Infrastructure:** Presence	• Stimulate and induce the presence of different infrastructures.	• Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy	• No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.	**Institutions:** Presence Quality	• Stimulate the presence of hard and soft institutions. • Do not allow institutions to be too weak.	• Memorandum/agreement; obligations; articulation of commitment.
	• Some resistance to change: the stakeholders cannot fully utilise the technology.	**Actors:** Capabilities	• Create spaces where actor capabilities can be improved.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
		Institutions: Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
	• Weak partnerships forming.	**Interactions:** Presence Quality	• Stimulate and induce interactions between diverse actors. • Block or address ties that are either too strong or too weak.	• Innovation platforms; collaborative research programmes; conferences. • Stimulate demand articulation: bottom-up knowledge creation; co-creation models; training, information and education sessions. • Bridging institutions (community liaison, local NGO). • Management of interfaces. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions.

6.4.3.3 CONCLUSION OF SYSTEMIC PROBLEMS AND INSTRUMENTS

To summarise, the main problem areas in Entrepreneurial activities (F1) are that the marginalised communities are not necessarily included in the Design and Development phases of the innovation. Their inclusion in earlier phases could however be beneficial as it could ensure that what is being taught or developed is of actual relevance to the community (meeting an actual need), and that it is being presented in a way that is applicable to the specific context. Knowledge development (F2) is blocked due to weak interactions between the university project teams and the marginalised community. Community members could be stimulated to participate in the innovation process by hosting focus groups, feedback sessions and meetings. There is little to no investment in this type of knowledge development from the government (F2) and the funding provided from the university is unsustainable and difficult to obtain (F5, F6). It is however, evident that UTIID projects have a very rich knowledge infrastructure and therefore emphasis should be placed on mechanisms to transfer this knowledge from the UTIIP project teams to the marginalised communities.

Knowledge is not effectively disseminated within the projects in our sample, as the marginalised community members lack capabilities and resources to communicate their needs (F4, F6) and students and university staff members lack the capabilities, opportunities and time to transfer knowledge to the community members (F3). Several projects did not provide any training or workshops during which the technical know-how behind the innovation and information regarding sustaining the innovation was disseminated to the marginalised community (F3).

Function 4, Guidance of search, had the following weaknesses in the projects in our samples: the projects developed innovations that were tested and implemented in the marginalised communities in order to 'prove a concept', but there were no/vague targets set regarding the further use of the technology; projects also lack a well-articulated vision and plan to scale; finally we also found that the marginalised communities were not always aware of the innovations and therefore did not show a lot of interest.

Market formation (F5) is hindered by a lack of incentives to create markets, researchers are incentivised to produce outputs and publications and funding for UTIID projects is unsustainable and difficult to come by. This is a problem that needs to be addressed by altering structural elements. Institutions need to be put in place that will incentivise university staff members to develop innovations that aim to educate marginalised communities.

Regarding the Mobilisation of resources (F6), six of the projects in our sample are stand-alone projects that do not have access to innovation platforms from which they can pool resources. Seven of the projects do not have sustainable sources of funding. These problems can be addressed by forming new types of partnerships, creating collaborative research programmes, applying for grants/loans or experimenting with different types of business models.

There are formal and informal partnerships forming between several actors that play a role in UTIID projects. There is however not always some form of agreement that dictates the UTIID projects' commitment to the marginalised community, especially after implementation of the innovation. These types of agreements both formal and informal will improve the legitimacy of the project.

6.5 Chapter Summary

This Chapter aimed to present the results gathered from 16 case studies. It started with an overview of the current state of monitoring and evaluation in the UTIID projects in our sample. It is evident that these type of projects perform monitoring and evaluation in the early phases of its life cycle, do not necessarily continue to evaluate after the project was successfully executed. Several barriers that inhibit evaluation in the later stages of the project's life cycle was identified. These include institutional, human, contextual and evaluation factors.

Next the interview transcripts were used to develop a typology of the types of inputs required for these projects and the outputs and outcomes produced by the projects. These typologies are useful as they can be used for the diagnosis of missing inputs/outputs/outcomes and provide technical advice.

Lastly, the analytical framework described in Chapter 5 was applied to the 16 case studies. This was done to: (1) determine whether the component-function approach is an appropriate approach to use for the analysis of UTIID projects, and (2) to develop a typology of systemic problems and systemic instruments that are coherent and specifically designed for UTIID projects. The component-function approach was useful in identifying the different components that make up the UTIID projects and to identify weaknesses within the system functions of each project. With the use of systemic problem categories and instruments we were able to propose changes that need to be made to system components in order to address the systemic weaknesses identified. This was done for each project. Using the systemic instruments suggested during the analysis of each project, a typology of systemic instruments was constructed for the evaluation tool.

CHAPTER 7 CONCLUSIONS PART 1: EVALUATION TOOL

Phase 1: Problem Statement & Systematic Review	Phase 2: Framework	Phase 4: UTIID evaluation tool
	Phase 3: Case Studies	

An evaluation tool is developed using qualitative research principles and results from 16 case studies in combination with literature on the component-function approach. The process map developed by Heeks *et al*. [69] was slightly altered and used as an overarching framework to guide the sequence of the evaluation tool which can be viewed in Figure 18.

Chapter 7 intends to achieve the following:

- Synthesise the Input, Output and Outcome Typologies with the findings from the application of the component-function approach to propose a comprehensive tool that can be used to evaluate UTIID projects and classify their outcomes.

7.1 The UTIID project evaluation tool

The following chapter describes the development of the tool to evaluate UTIID projects. The evaluation tool consists of (1) a typology of inputs according to each beneficiary; (2) a methodology to guide the evaluation of the project components and functioning; (3) a typology of project outputs according to each beneficiary, and (4) a typology of project outcomes. In order to open the 'black box' of evaluation and look at outcomes from every phase of the innovation process, it is important to look at the outcomes caused by system functions. In agreement with Heeks et al. [37] we propose that by opening the 'black box' it is possible to perform evaluations that are applicable on both the project- and systems-level. Using a process focused on both the components within a system as well as the changes that occur in the system functions will enable the translation of these outcomes back to a systems view. Therefore, Figure 18 shows the overarching structure of the proposed evaluation tool.

The following sections will describe the four steps of the evaluation tool. Starting with the input typology.

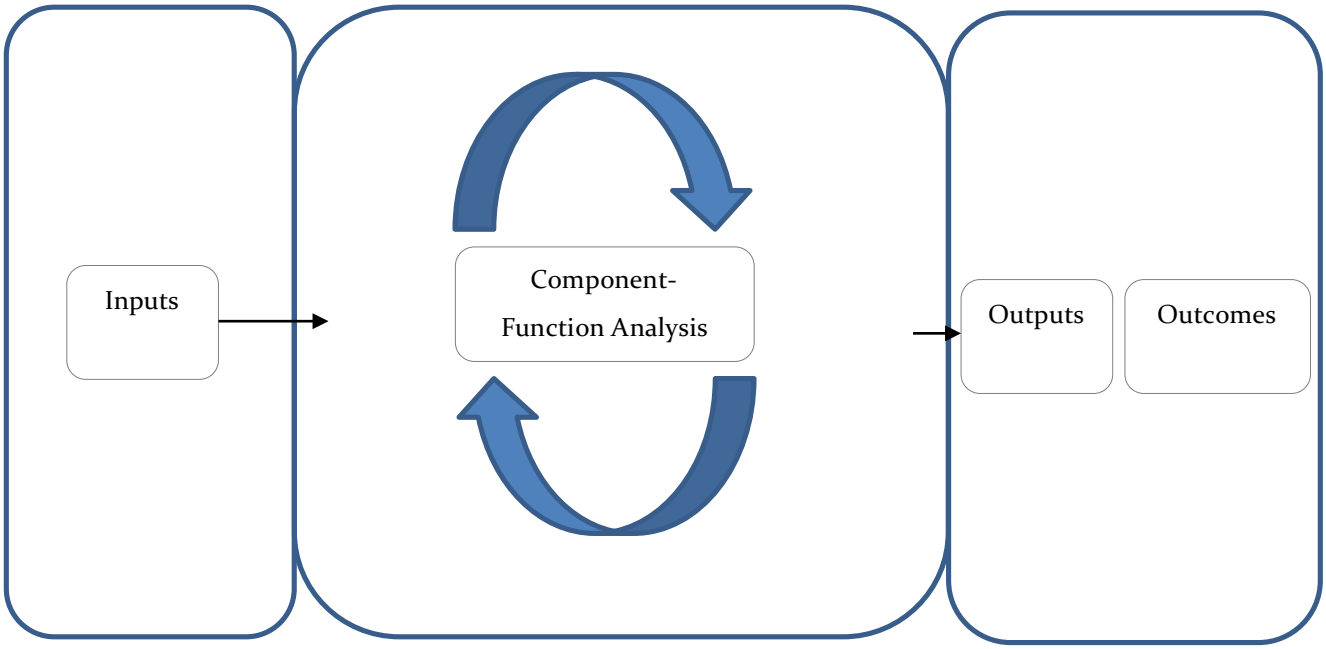


Figure 18: Overarching evaluation framework [69]

7.1.1 STEP 1: INPUTS

Step 1 is performed by completing the tasks shown in Figure 19: Step 1: Inputs:

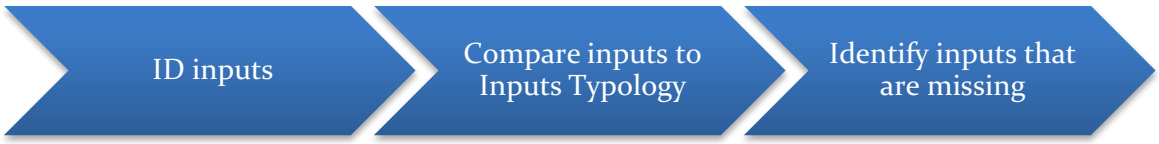


Figure 19: Step 1: Inputs

Identify all the inputs provided by each of the beneficiaries. These inputs can then be compared to the Inputs Typology to identify areas that require attention (see Table 40). It must however be emphasised that not all of the inputs in the typology are required for every project. Equipment for example would not be required for a service innovation. The typology however serves as a guide that can help the tool user to see what general inputs of UTIID projects are and from that he/she can discern whether some inputs are missing from the project. The last two columns of Table 40 are left open to be filled in by the tool user. The process of determining the Input Typology per beneficiary can be viewed in Appendix E.

Table 40: Evaluation of inputs using input typology

Beneficiaries	***Inputs typology***	***Actual inputs***	***Areas that require attention***
Marginalised Community	• Human Infrastructure • Social knowledge • Skills/Capabilities • Pre-established relationship with community • Design (inputs)	* To be filled in by tool user	* To be filled in by tool user
Academics/ Researchers	• Skills/Capabilities • Strategic leadership • Technical knowledge • Expert advice • Design • Design (inputs) • Human Infrastructure • Business knowledge		
Students	• Skills/Capabilities • Technical knowledge • Design • Design (inputs) • Human infrastructure		
University	• Equipment • Facilities • Funding • Institutional infrastructure • Business knowledge		

7.1.2 STEP 2: COMPONENT-FUNCTION ASSESSMENT

Identify components and perform functional assessment and analysis. This step consists of four stages described in Chapter 5 and shown in Figure 20.

Conclusions part 1: Evaluation tool

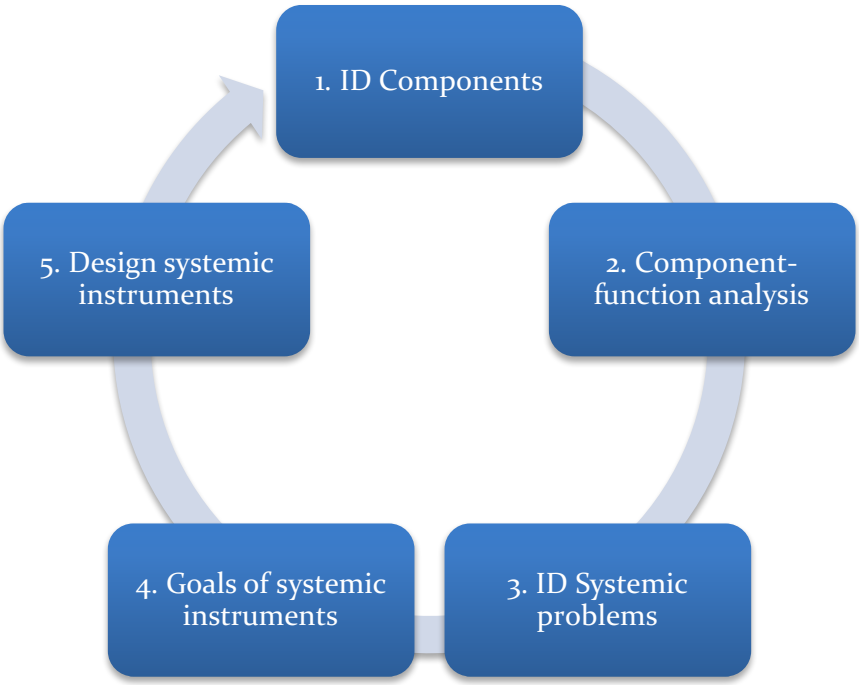


Figure 20: Framework for the analysis of innovation systems [141]

7.1.2.1 STAGE 1: IDENTIFY COMPONENTS

Use innovation system components as a guide to help us consider actors that are present and their capabilities. Define in which phase of the innovation process 'inclusion' occurred. (Invention, Design, Development, Production, Distribution, Adoption, Use). The component assessment can be guided with the use of the framework developed in Chapter 5. This step is completed by identifying the required components and their characteristics as summarised in Table 41.

Table 41: Component assessment [17], [40] , [38], [147]

Components	***Identify***
Actors	Actors in the UTIID projects and their roles (contributions) • UTIID project team. • Marginalised community members. • Other departments of the same university. • Other universities (SA). • International universities. • Government. • NGO's. • Businesses.
Relations	• Nature of relationships (formal, informal).

	• Collaborative networks and partnerships. • Partner contributions (funding, strategic leadership, equipment, facilities, expert advice). • Mode of community interaction (e.g. cooperatives).
Innovation	• Type of innovation (product/service, process or combination). • Degree of newness (incremental, radical). • Impact (disruptive, sustaining) • Intention of the innovation (development, education, research). • Driving mechanism, sustainability, possibility to scale.
Infrastructure	• Knowledge infrastructure. • Physical infrastructure. • Financial infrastructure.
Institutions	• Arranging the UTIID projects and community engagement.

7.1.2.2 STAGE 2: COUPLED COMPONENT-FUNCTION ANALYSIS

Use the Functions approach, with a specific focus on how this helps actors to engage in the IIS and with other. These are in essence the causes of the outputs and outcomes. Here we open the 'black box' to look at the processes within the innovation system and to determine the outcomes and outputs generated through system functions. This step is completed by identifying different indicators in each function and their as summarised in Table 42.

Table 42: Functional assessment [36], [41], [46], [68].

Function	***Identify***
F1: Entrepreneurial activity:	• Project champion • Community involvement • Experimentation • Entry
F2: Knowledge development:	• Sources and process of knowledge development • Knowledge infrastructure • Research collaboration
F3: Knowledge diffusion/ dissemination	• Focus of diffusion • Capacity for diffusion • Method for diffusion
F4: Guidance of search	• Targets • Recognised constraints • Belief in growth potential
F5: Market formation	• Institutional infrastructure

	• Market readiness
F6: Mobilisation of resources	• Access to capital • Business plan assessment • Public spending
F7: Creation of legitimacy	• Group confidence • Commitment • Partnership forming • Critical inputs

In this step the fulfilment of system functions within the UTIID projects are analysed. This is done by investigating the presence of specific indicators within projects that have to be present in order for the functions to be fulfilled. The indicators and scoring system are presented below in Table 43.

In this analysis, explanatory causes of insufficient system functioning are identified. This step aims to provide a clear overview of the most demanding problem areas that hinder innovation for inclusive development in the project under study.

Table 43: Analysis of system functions (adapted from [161])

Function	***Indicator***	***Value***
F1: Entrepreneurial activity *High score: 4*	Project champion Moderate project champion No project champion	+ 1 0 - 1
	Community involvement Moderate community involvement No community involvement	+ 1 0 - 1
	Experimentation Some extent of experimentation No experimentation	+ 1 0 - 1
	Partnerships with businesses Businesses are moderately involved No businesses involved	+ 1 0 - 1
F2: Knowledge development *High score: 2*	Knowledge infrastructure: Quality expertise, know-how and strategic information Moderate knowledge infrastructure Weak/no knowledge base	 + 1 0 - 1

	Research collaboration Community is moderately included in research No research collaboration	+ 1 0 - 1
F3: Knowledge dissemination *High score: 3*	Strong partnerships Moderate partnerships Weak/no partnerships	+ 1 0 -1
	Knowledge development is demand-driven. Knowledge development is moderately demand driven. Knowledge development is top-down (not demand-driven).	+ 1 0 -1
	Space for knowledge dissemination (Workshops, training, focus groups etc.) Moderate space created for knowledge dissemination. No space created for knowledge dissemination.	+ 1 0 - 1
F4: Guidance of search *High score: 3*	Targets set regarding the use of the technology. Vague targets for the use of technology. No targets, ad hoc implementation.	+ 1 0 - 1
	Well-articulated vision and belief in growth potential. Some vision and moderate belief in growth potential. No vision and no growth potential.	+ 1 0 - 1
	Articulation of interest from marginalised community. Some interest from marginalised community. No interest from marginalised community.	+ 1 0 - 1
F5: Market formation *High score: 5*	Incentives to promote market formation.	+ 1

	Some incentives to promote market formation. No incentives.	0 - 1
	Existing market. New market must be created.	+ 1 - 1
	Business plan assessed? Yes No	 + 1 - 1
	Sufficient human infrastructure Insufficient human infrastructure	+ 1 - 1
	Sufficient policy infrastructure Insufficient policy infrastructure	+ 1 - 1
	Sufficient technological infrastructure Insufficient human infrastructure	 + 1 - 1
	Sufficient financial infrastructure Insufficient financial infrastructure	+ 1 - 1
F6: Mobilisation of resources *High score: 3*	Sufficient financial infrastructure Moderate financial infrastructure Insufficient financial infrastructure	+ 1 0 - 1
	Public spending No public spending	+ 1 - 1
	Platform from which resources can be pooled. Small platform. Stand-alone project.	 +1 0 -1
	Do project outputs have a good reputation? Yes No	 + 1 - 1
F7: Creation of legitimacy *High score: 3*	Are there agreements, memorandums set up to dictate the commitment of the university to the community? Yes No	 + 1 - 1
	Partnerships (formal/informal) forming. No partnerships	 + 1 - 1

	No resistance to change, community adopts the innovation. Moderate adoption of innovation with some resistance to change. Resistance to change.	+1 0 -1

7.1.2.3 STAGE 3: IDENTIFY SYSTEMIC PROBLEMS

This stage seeks to provide explanations for the problem areas identified in Stage 2. Each weak function is analysed from the perspective of its components, specifically focusing on the presence/absence of components or the capabilities/quality of a component. Table 44 on the next page shows a typology of systemic problems identified from the 16 UTIID projects in our sample. The conceptualised categories developed by Wieczorek and Hekkert [43] and the developed typology can help UTIID projects identify and classify their systemic problems.

7.1.2.4 STAGE 4 AND 5: SYSTEMIC INSTRUMENTS

The goals of systemic instruments can easily be aligned with the systemic problems identified in Stage 3. The systemic problems and corresponding instrument goals are shown in Table 45 The systemic instruments need to be carefully selected in order to create opportunities and conditions for the improvement or creation of system functions.

Table 44: Categories of systemic problems identified from Wieczorek and Hekkert [43], and typology developed from UTIID case studies

Structure	***Systemic problem types***	***Description***	***Typology of systemic problems in UTIID projects***
Actors:	Presence	• Missing actors	• Community absent in Design and Development phases. • No/weak interaction between community and university project team.
	Capabilities	• Weak absorptive (learning) capacity. • Inability or weak competency to articulate needs/demands. • Inability or weak competency to develop strategies.	• Extent of experimentation is limited. • No space/opportunities created for knowledge transfer. • Some resistance to change: the stakeholders cannot fully utilise the technology due to weak competency.
Interactions:	Presence	• Weak or missing interactions due to: Lack of trust. Perceived distances between actors. Opposing objectives.	• Community absent in Design and Development phases. • No/weak interaction between community and university project team. • The Community is not involved in the research process. • Weak partnerships forming. • No real incentive to promote market formation. • Stand-alone project that does not form part of an innovation platform from which it can pool resources.
	Quality	• "Strong" network problems: Strong actors provide wrong guidance to other actors • "Weak" network problems: Weak interactions between actors that inhibits knowledge diffusion learning.	• Extent of experimentation is limited. • No space/opportunities created for knowledge transfer. • Lack of meaningful interactions that could result in 'learning-by-interacting'. • Weak partnerships forming.
Institutions:	Presence	• Missing institutions	• Community is unaware of the intervention in early phases. • The Community is not involved in the research process. • Marginalised community show little interest.

			• Limited belief in growth potential. • No market, new market has to be created. • Resistance to change: the stakeholders cannot fully utilise the technology. • No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.
	Quality	• Insufficient or poor institutions (hindering innovation).	• Knowledge dissemination is top-down; therefore, it is not 'inclusive'. • Vague targets for the use of technology, no M&E conducted beyond implementation. • No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.
Infrastructure:	Presence	• Missing infrastructures.	• Unsustainable source of funding. • Lack of business plan development. • Missing infrastructure (human, technological, financial).
	Quality	• Insufficient or poor infrastructure. • Vague targets for the use of technology, no M&E conducted beyond implementation.	• Extent of experimentation is limited. • No real incentive to promote market formation. • Lack of business plan development. • Insufficient infrastructure (human, technological, financial).

Table 45: Typology of systemic instruments for UTIID projects

Structure	***Systemic problem types***	***Systemic instrument goals***	***Systemic instruments***
Actors:	Presence	• Induce and stimulate the participation of several actors.	• Focus groups; feedback sessions; workshops. • New types of partnerships. Interactive actor involvement techniques.

Conclusions part 1: Evaluation tool

	Capabilities	• Create spaces where actor capabilities can be improved.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions.
Interactions:	Presence	• Stimulate and induce interactions between diverse actors.	• Innovation platforms; collaborative research programmes; conferences. • Bridging institutions (community liaison, local NGO).
	Quality	• Block ties that are either too strong or too weak.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Programme assessment and monitoring.
Institutions:	Presence	• Stimulate the presence of hard and soft institutions.	• Memorandum/agreement; obligations; articulation of commitment.
	Quality	• Do not allow institutions to be too weak.	• Focus groups; feedback sessions. • Awareness campaigns; information campaigns. •
Infrastructure:	Presence	• Stimulate and induce the presence of different infrastructures.	• Knowledge and financial infrastructure needs to be put in place in order to construct a business model. • Access to capital through grants/loans/funding; various business models.
	Quality	• Make sure that the infrastructure is of acceptable quality.	• Grants/ loans/funding to incentivise UTIID project and to employ full time staff members.

7.1.3 STEP 3: OUTPUTS

Figure 21 shows the tasks that need to be completed to execute Step 3.

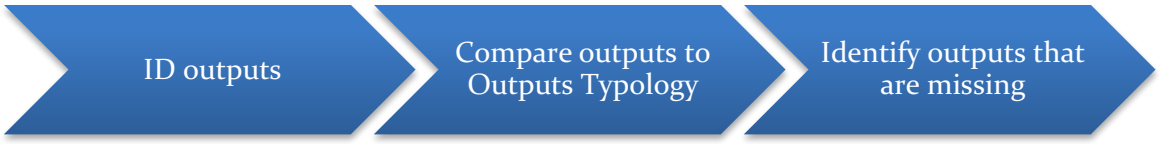


Figure 21: Step 3: Outputs

Tangible outputs of the UTIID project needs to be identified. As with the Input Typology, the Output Typology can be used to compare whether each of the beneficiary groups are getting advantageous outputs (see Table 46). Once again, the typology is not completely applicable to all projects as-is. It serves as an overarching framework that provides a typology of general outputs based on our sample. By comparing a projects outputs to the typology, specific outputs that are applicable but not present can be identified. The last two columns of Table 46 are left open to be filled in by the tool user.

Table 46: Evaluation of outputs using output typology

Beneficiaries	Outputs Typology	Actual Outputs	Areas that require attention
Marginalised Community	• Access to information • Alternative modes of education (more inclusive) • Built interventions • Clean water and sanitation • Designs • Electronic communication • Employment opportunities • Improved nutritional status • Inclusive medical treatment • Increased income per capita • More practical layout of settlement • Skills/ Capabilities	* To be filled in by tool user	* To be filled in by tool user
Academics/ Researchers	• Awards • Conference presentations • Masters • PhD's • Publications		
Students	• Conference presentations • Masters • PhD's • Publications • Practical experience • Course credits		
University	• Awards • Conference presentations • Masters • PhD's • Publications • Good reputation • CSR		

7.1.4 STEP 4: OUTCOME EVALUATION

Figure 22 shows the tasks that need to be completed to execute Step 4.

Figure 22: Step 4: Outcome evaluation

The outcomes are dependent on the outputs produced. The Outcome Typology presented in Table 47 serves as a framework to classify outcomes.

Table 47: Identification and classification of outcomes

	Market	***Non-market***
Built capital	• Water and sanitation • Buildings • Machinery • Roads • Electronic communications	• Contribution to regional governance and planning • Cohesive and secure environments • Improved health care facilities/treatment
Cultural capitals		• Language • Festivals • Shared identity • Greater cultural tolerance and enhanced democracy
Human capital	• Jobs created • Employability of graduated university students	• Investments in people: Learning, education, experiences, leadership development • Improved health • Improved safety • Faster and wider diffusion of new knowledge
Social capital	• CSR	• Sense of belonging • Trust • Networks • Community capacity building
Political capital		• The ability to influence the distribution of resources. • Voice • Power • Connections
Financial capital	• Funding • Grants and Loans • Investments • Higher earnings/cost savings	

Academic capital	• Publications • Conference presentations • R&D partnerships • Degrees • Research • Invention	• Faster and wider diffusion of new knowledge • Networks
Business capital	• Established businesses/corporations	

7.1.5 THE ASSEMBLED EVALUATION TOOL

The final evaluation tool is then summarised in **Error! Reference source not found.** It summarises the four main steps of the tool, starting off with (1) the Input typology, (2) the component-function analysis, (3) the Output typology and (4) the Outcome typology. Figure 23 summarised the objectives that can be achieved using the UTIID project evaluation tool.

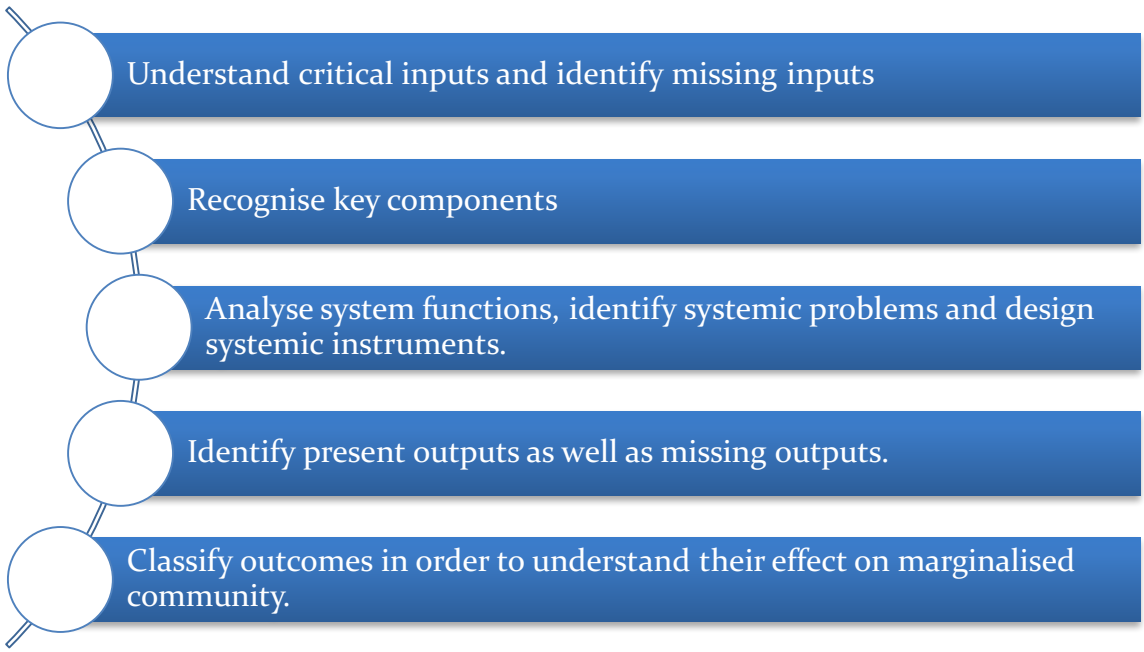
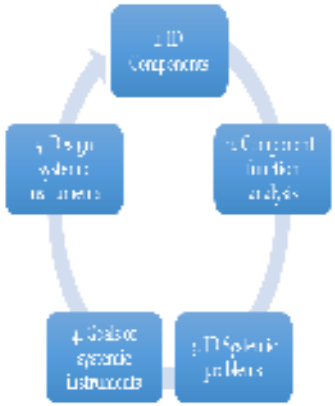


Figure 23: Objectives of UTIID project evaluation tool

Beneficiaries	Inputs typology
Marginalised Community	Human Infrastructure; Social knowledge; Skills/ Capabilities; Pre-established relationship with community; Design (inputs)
Academics/ Researchers	Skills/Capabilities; Strategic leadership; Technical knowledge; Expert advice; Design; Design (inputs); Human Infrastructure; Business knowledge
Students	Skills/Capabilities; Technical knowledge; Design; Design (inputs); Human infrastructure
University	Equipment; Facilities; Funding; Institutional infrastructure; Business knowledge



Beneficiaries	Outputs Typology
Marginalised Community	Access to information; Alternative modes of education (more inclusive); Built interventions; Clean water and sanitation; Designs; Electronic communication; Employment opportunities; Improved nutritional status; Inclusive medical treatment; Increased income per capita; More practical layout of settlement; Skills/ Capabilities
Academics/ Researchers	Awards; Conference presentations; Masters; PhD's; Publications
Students	Conference presentations; Masters; PhD's; Publications; Practical experience; Course credits
University	Awards; Conference presentations; Masters; PhD's; Publications; Good reputation; CSR

	Market
Built capital	Water and sa chinery; Roac tions
Human capital	Jobs created; ated universi
Social capital	CSR
Political capital	
Financial capital	Funding; Gra ments; Highe
Academic capital	Publications; tions; R&D p Research; Inv
Business capital	Established b

1. ID components **2. Component-function analysis** **3. ID Systemic problems in functions, the problems are related to components** **4 and 5.**

Components	Function	Identify
Actors	F1: Entrepreneurial activity:	Project champion; Community involvement; Experimentation; Entry
	F2: Knowledge development:	Sources and process of knowledge development; Knowledge infrastructure; Research collaboration
Interactions	F3: Knowledge diffusion/ dissemination	Focus of diffusion; Capacity for diffusion; Method for diffusion
	F4: Guidance of search	Targets; Recognised constraints; Belief in growth potential
Innovation	F5: Market formation	Institutional infrastructure; Market readiness
Infrastructure	F6: Mobilisation of resources	Access to capital; Business plan assessment; Public spending
Institutions	F7: Creation of legitimacy	Group confidence; Commitment; Partnership forming

Structure	Systemic problem types	Typology of systemic problems in UTIID projects	Systemi goals
Actors:	Presence	Community absent in Design and Development phases; No/weak interaction between community and university project team.	Induce the par several
	Capabilities	Extent of experimentation is limited; No space/opportunities created for knowledge transfer. Some resistance to change: the stakeholders cannot fully utilise the technology due to weak competency.	Create actor ca be impr
Interactions:	Presence	Community absent in Design and Development phases; No/weak interaction between community and university project team; The Community is not involved in the research process; Weak partnerships forming; No real incentive to promote market formation; Stand-alone project that does not form part of an innovation platform from which it can pool resources.	Stimula interact diverse
	Quality	Extent of experimentation is limited. No space/opportunities created for knowledge transfer. Lack of meaningful interactions that could result in 'learning-by-interacting'. Weak partnerships forming.	Block ti either t too wea
Institutions:	Presence	Community is unaware of the intervention in early phases.; The Community is not involved in the research process; Marginalised community show little interest; Limited belief in growth potential; No market, new market has to be created; Resistance to change: the stakeholders cannot fully utilise the technology.; No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.	Stimula ence of institut
	Quality	Knowledge dissemination is top-down; therefore, it is not 'inclusive'; Vague targets for the use of technology, no M&E conducted beyond implementation; No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.	Do not tions to
Infrastructure:	Presence	Unsustainable source of funding; Lack of business plan development; Missing infrastructure (human, technological, financial).	Stimula the pre ent infr
	Quality	Extent of experimentation is limited.	

7.2 Chapter summary

This chapter provided a description of the final proposed evaluation tool. It described the four main steps that the tool is made up of namely, (1) Input Typology, (2) Component-function analysis, (3) Output typology and (4) Outcome typology. Instructions were given on how to execute each step. Finally, the objectives of conducting evaluation using the UTIID project evaluation tool were summarised as: gaining an understanding of critical inputs and identifying missing inputs; recognising key components; understanding and measuring project functioning; understanding outputs and identifying missing outputs and lastly; classifying outcomes in order to understand the effect that a project has had on a marginalised community.

CHAPTER 8 CONCLUSIONS PART 2

The final chapter concludes this study with a concise summary of the research conducted and the findings of the study. The limitations of this study as well as recommendations for future work is discussed.

Chapter 8 intends to achieve the following:

- Provide a summary of the study and the results obtained.
- Describe conclusions deducted from the study and its findings.
- Provide recommendations for future work.

8.1 Research summary

The primary aim of this study was to propose a tool for the evaluation of UTIID projects and their outcomes. The research methodology consisted of four main phases namely:

1. Problem statement and systematic review.
2. Develop an analytical framework.
3. Perform case studies.
4. Develop an evaluation tool.

Table 48 shows how the different chapters in this thesis contribute to the research method described in Chapter 2.

Table 48: Research summary

Phase	*Execution*	*Chapters*
1. Problem statement and systematic review	• Background on developmental universities and the pilot project on UTIID projects conducted in 2014 was discussed. • The main aim of the research was described along with research objectives.	Chapter 1
	• Innovation system perspective was introduced.	Chapter 3
	• Conducted a systematic literature review on the evaluation of innovation systems was conducted. 106 studies were reviewed, and nine evaluation approaches were identified from literature. Each of the nine approaches were assessed using a pre-defined criterion. The innovation system component-function approach was identified as the most appropriate approach to evaluate inclusive innovation systems and ultimately, UTIID projects.	Chapter 4

2. Analytical framework	• A literature review was conducted on the component-function approach. An analytical framework developed by Wieczorek and Hekkert [43] was used to structure the approach.	Chapter 5
3. Case studies	• In Phase 3, 16 UTIID projects were identified and the project leaders were interviewed in order to collect data. The interview transcripts were deductively analysed in order to achieve the following objectives: o The current state of monitoring and evaluation within UTIID projects was investigated. o Input, output and outcome typologies were constructed from the 16 UTIID projects in our sample. o The component function approach was validated by applying it to 16 case studies. From this step, a typology systemic problems and instruments for UTIID projects was developed.	Chapter 6
4. Evaluation tool	• In phase 4 the evaluation tool is assembled and a stepwise explanation of the tool is provided.	Chapter 7

8.2 General conclusions with reference to the research objectives

The primary aim of this research was to develop a tool that could be used to evaluate UTIID projects. In an effort to do so, this research set out to achieve the following objectives:

1. Conduct a systematic literature review to identify an appropriate methodology that can be adapted for the evaluation of UTIID projects.
2. Evaluate monitoring and evaluation practices in current UTIID projects through in-depth case studies.
3. Construct Input, Output and Outcome typologies based on the UTIID project case studies that can be used for diagnosis and technical advice in future UTIID projects.
4. Validate the component-function approach (identified in Objective 1) as an applicable approach for the evaluation of UTIID projects by applying it to case studies.
5. Synthesise the findings from Objective 2 to 4 to propose a comprehensive tool that can be used to evaluate UTIID projects and classify their outcomes.

The following sections will discuss general conclusions with relevance to each of the five objectives.

8.2.1 CONCLUSIONS RELEVANT TO OBJECTIVE 1

Objective 1
Conduct a systematic literature review to identify an appropriate methodology for the evaluation of inclusive innovation systems that can be applied to the evaluation of UTIID projects.

With reference to the first objective**,** an extensive systematic literature review of 106 studies was conducted. The innovation system component function approach was identified as the most appropriate approach to use for the evaluation of UTIID projects as this approach is actor-oriented, can analyse complex relations between actors, makes use of rich qualitative data and is process focussed.

An in-depth literature review of the component-function approach was conducted in Chapter 5. This chapter showed that the coupled component function approach is a promising tool to use for the evaluation of UTIID projects.

8.2.2 CONCLUSIONS RELEVANT TO OBJECTIVE 2

Objective 2
Evaluate monitoring and evaluation practices in current UTIID projects through in-depth case studies.

The evaluation model designed by Mouton [166] was used to determine the current state of monitoring and evaluation in UTIID projects. Interview transcripts were used to determine in which phase of its life cycle each project is, and whether it is conducting the corresponding stage of comprehensive evaluation. In summary, we found that projects that were in the conceptualisation, pilot or mature phases of its life cycle were performing the relevant monitoring and evaluation. Projects that were successfully executed and now fall within the "Outcome/Effect" phase of its life cycle were however not conducting outcome evaluations. Several barriers that inhibit outcome evaluation was also identified. These findings support the initial problem identified in Chapter 1; that there exists a gap in literature regarding the evaluation of UTIID projects and their outcomes.

8.2.3 CONCLUSIONS RELEVANT TO OBJECTIVE 3

Objective 3
Construct Input, Output and Outcome typologies based on the UTIID project case studies that can be used for diagnosis and technical advice in future UTIID projects.

The interview transcripts were deductively analysed to identify all the inputs, outputs and outcomes of the UTIID projects in our sample. Using this data, three typologies were constructed. The advantage of these typologies are that they provide a checklist of common inputs and outputs as well as outcome categories that can be associated with a UTIID projects. These typologies can be used to identify areas that require attention (missing inputs/ outputs) and to classify the outcomes of the project.

8.2.4 CONCLUSIONS RELEVANT TO OBJECTIVE 4

Objective 4
Validate the component-function approach (identified in Objective 1) as an applicable approach for the evaluation of UTIID projects by applying it to case studies.

An analytical framework with five stages was introduced in Chapter 5. This framework emphasises that it is necessary to link functions to the components within the system, as a function can only be changed by altering components within the system. The analytical framework was applied to 16 UTIID projects. The analysis entailed the identification of system components and functions, followed by an analysis of the performance of system functions. Function weaknesses were successfully explained by means of systemic problems. These systemic problems were expressed in terms of a specific types (presence, capacity, quality) that are linked to components of the system (actors, interactions, institutions and infrastructure). A typology of systemic problems was constructed using the results of the component-function analysis. The list of systemic instrument goals and systemic instruments developed by Wieczorek and Hekkert [43] was used and adapted to suggest specific systemic instruments for the systemic problems identified in the 16 UTIID projects.

It can therefore be concluded that the analytical framework is an effective approach to analyse UTIID projects (identifying system weaknesses) and suggesting ways to improve the projects (systemic instruments).

8.2.5 CONCLUSIONS RELEVANT TO OBJECTIVE 5

Objective 5
Synthesised the findings from Objective 2 to 4 to propose a comprehensive tool that can be used to evaluate UTIID projects and classify their outcomes.

The final objective of this research study was to use the findings from the Objectives 1-4 to construct a tool that can be used to evaluate UTIID projects and their outcomes. This was done by synthesising the Input, Output and Outcome typologies with the analytical framework discussed in Chapter 5. This tool is summarised in Section 7.1.5.

8.3 Shortcomings and limitations

As previously mentioned in Chapter 1, the main limitation of this study is that the projects were analysed from the perspective of a single actor within the project, the project leader. This was however sufficient as he projects leaders were the most influential actors in these projects.

Another limitation is that the amount of UTIID projects in our sample is not statistically significant within the total portfolio of university projects. These types of projects are quite rare in universities and not widely advertised so it was difficult to identify projects. The study was also limited to four universities in the Western Cape region of South Africa.

The next section will provide recommendations for future studies that could set out to address the limitations of this study.

8.4 Recommendations for future studies

In the course of this study, we found that there is a need for more research regarding aspects of the component-function approach such as the indicators of how to assess functionality and impact classification measures. We propose that further studies apply a systematic learning process in order to improve our understanding of the practical application of such an approach. The component-function approach needs to be applied using primary data in several sectors in order to start revising this approach and constructing practical evaluation frameworks. This could help unpack the component-function approach to develop a list of impact classification measures that are applicable on both the project- and systems-level. Previous research shows that by opening the 'black box' i.e. looking at inclusions in the process it is possible to develop such a list [38]. We have started by proposing an evaluation tool that can evaluate UTIID projects and classify their outcomes.

Future studies could also set out to apply the component-function analysis to more UTIID projects, but gathering data from more than one of the actors within the system in order to get a more holistic view of the system and its weaknesses. Finally, future studies could aim to analyse a larger sample of UTIID projects from universities across SA.

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Appendix A: SYSTEMATIC LITERATURE REVIEW

i. Database worksheets

Table 49 shows an example of a filled out database worksheet that was used to track the data sources in the systematic review. This was done so that the review can be replicated. The results of all the database worksheets are summarised in Table 50.

Table 49: Database worksheet: Scopus

Title: Scopus Search **Overview of Search Strategy:**			
Search terms			
Method/ Approach Innovation Systems/ Systems of Innovation Evaluation/Analysis			
Database Searches			
Database Name	Internal code for Search	Date of Search	Name of Searcher
Scopus	S_1	2015/07/29	Louisa
Notes about the search			
Database Supplier (e.g. ProQuest)	Scopus		
Language Indexed	None		
Notes about the search:			
Purpose	Initial document collection i.e. Phase 1		
Results:			
Number of records retrieved	176		
Final set of records (after duplicate check)			
Original Search Strategy (cut and paste from search history)			
(TITLE-ABS-KEY (method OR approach) AND TITLE-ABS-KEY ("Innovation system*" OR "system* of innovation") AND TITLE ("evaluat*" OR "analys*"))			

Table 50: Summary of database worksheet results

Database	*Number of records retrieved (after duplicates removed)*
Scopus	176
ScienceDirect	36
Web of science	53
Academic Search Premier	8
Emerald	2
ProQuest	68

Total records retrieved	**249**

ii. Final studies included in the systematic review

Table 51: Studies included in the systematic review

Number	Author	Year
1	Aggarwal, a.	2001
2	van Alphen, Klaas; van Ruijven, Jochem; Kasa, Sjur; Hekkert, Marko & Turkenburg, Wim	2009
3	Amankwah, K.; Klerkx, L.; Oosting, S.J. J.; Sakyi-Dawson, O.; van der Zijpp, A.J. J. & Millar, D.	2012
4	de Araujo, Fernando Oliveira; Dalcol, Paulo Roberto Tavares & Longo, Waldimir Pirroe	2011
5	Asa, Asa Romeo; Prasad, Navneel Shalendra & Htay, Maw Maw	2013
6	Autio, Erkko	1998
7	Bajmocy, Zoltan; Lukovics, Miklos & Vas, Zsofia	2010
8	Bellandi, Marco & Caloffi, Annalisa	2010
9	Bergek, Anna; Jacobsson, Staffan; Carisson, Bo; Lindmark, Sven; Rickne, Annika; Carlsson, Bo; Lindmark, Sven & Rickne, Annika	2008
10	Blum, Nicola U.; Bening, Catharina R. & Schmidt, Tobias S.	2015
11	Breukers, Sylvia; Hisschem{\{o}}ller	2014
12	Busse, M.; Schwerdtner, W.; Siebert, R.; Doernberg, A.; Kuntosch, A.; K{\{o}}nig	2015
13	Cantner, Uwe & Graf, Holger	2004
14	Cao, Jing; Shen, Ming & Fan, De Cheng	2011
15	Castellacci, Fulvio & Natera, Jose Miguel	2013
16	Chang, Pao-Long & Shih, Hsin-Yu	2005
17	Chang, Pao-Long & Shih, Hsin-Yu	2004
18	Chen, Heng; Xu, Ruishu & Feng, Zhijun	2013
19	Chen, Xi & Zhao, Shuming	2012
20	Chen, Zhan & Xiao-hong, Ren	2011
21	Choi, C. W.; Shin, J. S.; Yoon, B. G.; Lee, W. Y. & Park, Y. T.	2004
22	Chuang, Yun-Wen; Lee, Ling-Chu; Hung, Wen-Chi & Lin, Pin-Hua	2010
23	Cincera, Michele; Bikar, Verena & Capron, Henri	2006
24	de Noronha Vaz, T.; Galindo, P. V.; de Noronha Vaz, E. & Nijkamp, P.	2013
25	Diez, Maria Angeles	2001
26	van der Duin, Patrick & Hermeler, Hans	2014
27	Duman, Yavuz Selman	2011
28	Edquist, Charles	2001
29	Erac	2012
30	Feller, Irwin	2007
31	Fischer, Bruno & Molero Zayas	2012
32	Foran, Tira; Butler, James R.A.; Williams, Liana J.; Wanjura, Wolf J.; Hall, Andy; Carter, Lucy & Carberry, Peter S.	2014
33	Foster, Christopher & Heeks, Richard	2013
34	Fu, Wei-zhong & Han, Cheng-yan	2010
35	Ghazinoory, Sepehr & Ghazinoori, Soroush	2006

36	Godin, Benoit	2007
37	Guan, Shiping & Zhu, Weidong	2009
38	Hall, Andy & Dorai, Kumuda	
39	Han, Yu	2008
40	Hekkert, Marko P. & Negro, Simona O.	2011
41	Hekkert, M. P.; Suurs, R. A A; Negro, S. O.; Kuhlmann, S. & Smits, R. E H M	2007
42	Heydebreck, Peter	2014
43	Horton, Douglas & Mackay, Ronald	2003
44	Hung, Shih-Chang	2000
45	Intxaurburu, Gurutze & Olaskoaga, Jon	1999
46	Iqbal, Abeda Muhammad; Khan, Adnan Shahid; Bashir, Farrukh; Senin, Aslan Amat; Muhammad Iqbal, Abeda; Shahid Khan, Adnan; Bashir, Farrukh & Amat Senin, Aslan	2015
47	Kai, Sun; Xiao-feng, Ju; Yu-hua, Li; Sun, Kai; Ju, Xiao-feng & Li, Yu-hua	2006
48	Kamp, Linda M.	2008
49	Kim, Ji-hyun; Bae, Sung Joo & Yang, Jae-Suk	2014
50	Koenig, Bettina; Kuntosch, Anett; Bokelmann, Wolfgang; Konig, Bettina; Kuntosch, Anett; Bokelmann, Wolfgang; Doernberg, Alexandra; Schwerdtner, Wim; Busse, Maria; Siebert, Rosemarie; Koschatzky, Knut & Stahlecker, Thomas	2012
51	Kohler, J.hler, Jonathan; Schade, Wolfgang; Leduc, Guillaume; Wiesenthal, Tobias; Schade, Burkhard; Tercero Espinoza, Luis; Koehler, Jonathan; Schade, Wolfgang; Leduc, Guillaume; Kohler	2013
52	Kratke, S.	2010
53	Lai, Xianjin; Ye, Zhonghua; Xu, Zhengzhong; Husar Holmes, Maja & Henry Lambright, W.	2012
54	Lamprinopoulou, Chrysa; Renwick, Alan; Klerkx, Laurens; Hermans, Frans & Roep, Dirk	2014
55	Lan, Jun; Jun, Lan & Ieee	2008
56	Larsen, K; Kim, R & Theus, F	2009
57	Lee, Ting Lin	2006
58	Li, Shou-wei	2009
59	Li, Zhao	2011
60	Lundquist, Karl-Johan & Trippl, Michaela	2013
61	Lundvall, Bengt-{\AA}ke & Christensen, Jesper Lindgaard	1999
62	Markard, Jochen; Stadelmann, Martin & Truffer, Bernhard	2009
63	Markard, Jochen & Truffer, Bernhard	2008
64	Martins Rodriguez, Blanca & Mar{\'{\i}}a Viedma Mart{\'{\i}}, Jos{\'{e}}	2006
65	Matatkova, Katerina & Stejskal, Jan	2013
66	van Mierlo, B.; Arkesteijn, M. & Leeuwis, C.	2010
67	van Mierlo, Barbara; Leeuwis, Cees; Smits, Ruud & Woolthuis, Rosalinde Klein	2010
68	Millstone, Erik; Van Zwanenberg, Patrick & Marshall, Fiona	2010
69	Miyazaki, Kumiko & Islam, Nazrul	2007
70	Mohtarami, Amir; Hosseini, Seyed Hamid Khodadad & Kandjani, Hadi	2013
71	Molero, Jose & Garcia, Antonio	2008
72	Mostafavi, Ali; Abraham, Dulcy M.; DeLaurentis, Daniel & Sinfield, Joseph	2011
73	Naghizadeh, Reza; Elahi, Shaban; Manteghi, Manoochehr; Ghazinoory, Sepehr & Ranga, Marina	2014
74	Nan, Yufan & Tian, Yuying	2011
75	Nauwelaers, Claire & Reid, A.	1995

76	Perez-Astray, Braulio & Babio, Nuria Calvo	2011
77	Parsons, Beverly	2001
78	Praetorius, Barbara; Martiskainen, Mari; Sauter, Raphael & Watson, Jim	2010
79	Prest, Michael Keenan (OECD)	2005
80	Qi, Liu; Zibiao, Li & Baomin, Hu	2012
81	Rametsteiner, Ewald & Weiss, Gerhard	2006
82	Randelli, Filippo & Rocchi, Benedetto	2015
83	Rose, J & Winter, K	2015
84	Russo, Margherita & Rossi, Federica	2009
85	Samara, Elpida; Georgiadis, Patroklos & Bakouros, Ioannis	2012
86	Schut, Marc; Klerkx, Laurens; Rodenburg, Jonne; Kayeke, Juma; Raboanarielina, M; Adegbola, Patrice Y.; Ast, Aad Van; Bastiaans, Lammert	2014
87	Schut, Marc; Rodenburg, Jonne; Klerkx, Laurens; Kayeke, Juma; van Ast, Aad & Bastiaans, Lammert	2015
88	Seidel, Uwe; Muller	2013
89	Southon, Gray	1999
90	Sun, Lijie	2011
91	Svarc, Jadranka; Laznjak, Jasminka & Perkovic, Juraj	2011
92	Temel, Tugrul T; Janssen, Willem & Karimov, Fuad	2002
93	Wang, Ai-feng & Li, Shao-bo	2009
94	Wang, Yuandi; Vanhaverbeke, Wim & Roijakkers, Nadine	2012
95	Wieczorek and Hekkert	2012
96	Wood, Brennon A; Blair, Hugh T; Gray, David I; Kemp, Peter D; Kenyon, Paul R; Morris, Steve T & Sewell, Alison M	2014
97	World Bank	2012
98	World Bank	2009
99	World Bank	2007
100	World Bank	2001
101	Xie, Yumin	2011
102	Xuguang, Xie; Zaixu, Zhang & Jing, Zhang	2011
103	Yu, Yan; Sun, Huimin; Yan, Yu & Huimin, Sun	2009
104	Yuri, Doroshenko; Irina, Somina & {\v{Z}}ivota, Radosavljevi{\'{c}}	2011
105	Zhang, Zhenzhu & Mu, Jing	2010
106	Zhao, S.L. L.; Cacciolatti, L.; Lee, S.H. H. & Song, W.	2015

iii. Evaluation methodology used in each study

Table 52 is an output produced from Atlas.ti. It lists an identifier for each of the included studies along with the method that was used to evaluate/analyse the IS in the study. In the third column, these methods are categorised according to the nine methods mostly found in the studies in this review.

Table 52: Identification of evaluation methodology

	Authors	Methods	Method categories
1	P 1: Aggarwal2001.pdf	evaluation method: comparative analysis	Comparative
2	P 1: Alphen2009.pdf	approach: functions approach	TIS

3	P 2: AlamHossainMondal2010.pdf	approach: functions approach	TIS
4	P 2: Assa2013.pdf	approach: NIS approach	Regime
5	P 3: Amankwah2012.pdf	method: casual diagram	SD
6	P 3: Crasemann2012.pdf		Peer Review
7	P 4: Autio1998.pdf	evaluation method: to evaluate RIS	Component
8	P 4: deLucio.pdf		R&D Outputs
9	P 5: Bajmocy2010.pdf	approach: RIS approach	Regime
10	P 5: Doroshenko.pdf		Comparative
11	P 6: Edquist2001.pdf	method: to analyse policy	Component-function
12	P 7: Bellandi2010.pdf	evaluation method: to evaluate policy	Component
13	P 7: FosterHeeks2013.pdf		Component
14	P 8: Bergek2008.pdf	evaluation approach: functional dynamics approach	TIS
15	P 8: Godin2007.pdf	evaluation method: for evaluation of IS interventions	Historical overview of NIS approach
16	P 9: Hall_InvestmentSourcebook.pdf		Component-function
17	P10: Blum2015.pdf	approach: functions approach	TIS
18	P10: InnovationSystemsWorldBank.pdf	evaluation method: for evaluation of TIS	Literature: Lessons learnt from project evaluation
19	P100: Zhao2015.pdf	approach: RIS approach	Component
20	P11: Breukers2014.pdf	approach: functions approach	TIS
21	P11: Lai2012.pdf	approach: functions approach	TIS
22	P12: Busse2015.pdf	approach: IDIVIER for sectoral IS	Component
23	P12: Lamprinopoulou2014.pdf	evaluation method: for evaluation of RIS	Component-function
24	P13: Cantner2004.pdf	method: social network analysis	SD
25	P13: OECD2010.pdf		Component
26	P14: Cao2011.pdf	evaluation model: C2R input - output model	DEA
27	P14: Parsons2012.pdf	Approach: NIS approach (indicator-based analysis of approach: NIS approach)	SD
28	P15: Castellacci2013.pdf	model: to analyses dynamics of approach: NIS approach	SD
29	P15: Seidel2013.pdf		Regime
30	P16: Chang2004.pdf	approach: comparative analysis	Comparative
31	P16: UU2011.pdf		TIS
32	P17: Chang2005.pdf	approach: IDIVIER for sectoral IS	Component
33	P17: WorldBank2005.pdf		TIS
34	P18: Chen2011.pdf	evaluation: index for innovative capabilities with AHP method	AHP
35	P18: WorldBank2006.pdf		Component-function
36	P19: Chen2012.pdf	method: DEA	DEA
37	P19: WorldBank2007.pdf		Literature: TIS
38	P20: Chen2012a.pdf	evaluation method: CAS and fuzzy mathematics	Fuzzy Catastrophe Model
39	P20: WorldBank2009.pdf		Component-function
40	P21: Choi2004.pdf	method: social network analysis	SD

41	P21: WorldBankAgricultural Innovation Sourcebook.pdf		Literature: AIS
42	P23: CHUANG2010.pdf	method: RCA and clustering for approach: NIS approach	Comparative
43	P24: Cincera2006.pdf	evaluation: framework to evaluate STI performance	Component
44	P26: DeAraujo2011.pdf	approach: IDIVIER for sectoral IS	Component
45	P27: DeNoronhaVaz2013.pdf	approach: external Logistics Bi-plot method for RIS	Component-function
46	P28: Dezhong2014.pdf	evaluation model: two-phase TOPSIS and DEA	DEA
47	P29: Diez2001.pdf	evaluation approach: participatory evaluation	Component-function
48	P30: Duman2011.pdf	approach: RIS approach	Regime
49	P31: Feller2007.pdf	approach: NIS approach	Component
50	P32: Fischer2012.pdf		Component
51	P33: Foran2014.pdf	4 frameworks	Component-function
52	P34: Fu2010.pdf	evaluation model: factor analysis to evaluate role of government in RIS	Component
53	P35: Ghazinoory2006.pdf	framework: SWOT to analyse NIS	SWOT
54	P36: Guan2009.pdf	evaluation model: DEA method	DEA
55	P37: Han2006a.pdf	framework: to analyse knowledge flow	Patent network analysis
56	P39: Hekkert2007.pdf	approach: IS approach	Component
57	P40: Horton2003.pdf	evaluation method: to evaluate agricultural research	Component-function
58	P42: Hung2000.pdf	approach: institutional blocks	Component
59	P43: Intxaurburu1999.pdf		Component
60	P44: Iqbal2015.pdf	evaluation approach: systems dynamics	SD
61	P45: Kai2006.pdf	method: DEA	DEA
62	P46: Kamp2008.pdf	approach: approach: functions approach	TIS
63	P47: Kim2014.pdf	model: GA-based innovation modeling	Triple Helix
64	P48: Koenig2012.pdf	methods: mixed methods research	Component
65	P49: Kohler2013.pdf	approach: SIS approach with Functional approach	TIS
66	P50: Kratke2010.pdf	evaluation method: network analysis	SD
67	P51: Lan2008.pdf	approach: system dynamics	SD
68	P52: Lee2006.pdf	approach: system dynamics	SD
69	P53: Li2009b.pdf	method: IDEF for analysis of TIS	TIS
70	P54: Li2011.pdf	evaluation method: to evaluate RIS	Factor analysis
71	P55: Lundquist2013.pdf	model: on different types of regional IS's	Comparative
72	P56: Lundvall1999.pdf	approach: RIS approach	Component
73	P57: Markard2008.pdf	approach: TIS approach (actor orientated)	Component-Function
74	P58: Markard2009.pdf	method: for the analysis of development of TIS	Variation analysis
75	P59: MartinsRodriguez2006.pdf	benchmarking: competitiveness of approach: RIS approach	Comparative
76	P60: Matatkova2013.pdf	evaluation method: to evaluate RIS	Component-function
77	P61: Millstone2010.pdf	evaluation approach: participatory evaluation	Component

78	P63: Miyazaki2007.pdf	IS approach	Comparative
79	P64: Mohtarami2013.pdf	approach: approach: functions approach	TIS
80	P65: Molero2008.pdf		Sectoral Taxonomy
81	P66: Mostafavi2011.pdf	system of systems approach	Component-function
82	P67: Naghizadeh2014.pdf	approach: RIS approach: co-word and meta-synthesis	Regime
83	P68: Nan2011.pdf	evaluation method: AHP-TOPSIS to evaluate RIS performance	AHP
84	P69: Perez-Astray2011.pdf	relationship promoter univ/industry	Triple Helix
85	P70: Praetorius2010.pdf	approach: approach: functions approach	TIS
86	P72: Qi2012.pdf	R&D (innovation) spillover effect model	input-output
87	P73: Rametsteiner2006.pdf	evaluation method: to evaluate policy	Component-function
88	P74: Randelli2015.pdf	approach: TIS approach (actor orientated)	Component-Function
89	P75: Rose2015.PDF	gap analysis (IS approach)	Component-function
90	P76: Russo2009.pdf	evaluation: framework to evaluate structural components of policy programmers	Component
91	P77: Samara2012.pdf	approach: system dynamics	SD
92	P78: Schut2014.pdf	method: Rapid Appraisal	Regime
93	P79: Schut2015a.pdf	method: Rapid Appraisal	Regime
94	P80: Shih2009.pdf	method: social network analysis	SD
95	P81: Southon1999.pdf		TIS
96	P83: Sun2011.pdf		Fuzzy Board Method
97	P84: Svarc2011.pdf	evaluation approach: social evaluation	Component
98	P85: Temel2003.pdf	graph approach	Component
99	P86: VanderDuin2014.pdf	evaluation model: actor-oriented CIS model	Component
100	P87: VanMierlo2010.pdf	evaluation method: Reflexive process monitoring	SD
101	P88: VanMierlo2010a.pdf	evaluation: framework to evaluate intervention programs (does it improve learning)	Component
102	P90: Wang2009.pdf	index system for approach: RIS approach structure	Component
103	P91: Wang2012.pdf		Regime
104	P92: Wieczorek2012.pdf	method: component-function	Component-function
105	P93: Xie2011.pdf	evaluation model: close value model to evaluate enterprise IS	Component
106	P94: Xuguang2011.pdf	approach: comparative analysis	Comparative

Appendix B: INTERVIEW QUESTIONNAIRES AND TRANSCRIPTS

i. Interview questionnaires

These interview transcripts were constructed by project team which consisted of the author, Louisa Botha and the research team that was involved in the pilot study namely, Dr S Grobbelaar, Dr M Dijkstrerhuis and Prof R Tijssen.

Interview Questionnaire

Technology-based inclusive innovations at universities

in the Western Cape, South Africa

Interview questionnaire for < project name >

1. When did this inclusive innovation project/process start (year, month)?

   ☐

2. What is/was your role in the project?

3. What are the main objectives of the project?

4. How would you describe the nature of the project?

   ☐ Commercial/for profit ☐ Developmental/non-profit ☐ Mix of for profit and non profit

   ☐ Other, namely: _____

5. Who, besides you/your department, has contributed to the project?

   ☐ Other department/unit(s) at your university

   ☐ Other South African university/ies

   ☐ International university/ies

   ☐ Local community/ies

   ☐ Government (local/provincial/national)

   ☐ Business/es

   ☐ NGOs

☐ Other, namely: _____

6. What have the university contributions been to this innovation (yours and any other university representatives)?

7. Please provide us, if you can, with an indication of the project budget (**including** the value of in-kind contributions):

   ☐ Less than R10,000 ☐ Between R10,000 and R100,000

   ☐ Between R100,000 and R1 million ☐ Between R1 million and R10 million

   ☐ More than R10 million

8. What have been the critical inputs into the innovation process, and who has delivered these inputs?

For example: money; infrastructure & equipment; knowledge (e.g. technical, business, social/context, regulatory); IP rights; access to end-users or other stakeholders; any type of skills.

9. Has the innovation been tested? If so, where and how?

10. Has the innovation been implemented (i.e. made available to the target market)?

☐ Yes – *please proceed to question 4*

☐ No – *please proceed to question 6*

11. How many people are using the innovation (approximately)?

☐

12. What are the critical factors in people's decision to use the innovation?

13. What are you aiming for with this innovation; i.e. what would you say constitutes a success?

14. Are any quantitative or qualitative performance data recorded? If so, what?

15. What have been the outcomes so far? [If not measured, then based on anecdotal evidence.]

16. In your opinion, which decisions/choices in the innovation process have been critical in terms of its outcomes and how?

17. What have the outcomes been (so far) for the university/ies?

For example: research publications, research presentations, R&D partnerships, patents, student education, money, equity, competencies.

ii. Interview transcripts

This section contains all the transcripts of the interviews conducted with the 16 UTIID projects in our sample. Some names and affiliations have been covered to maintain confidentiality.

Project A1

Interview date: Tuesday 7 June 2016

When did the project start?
2011

What are your roles?
Project co-ordinators

Main objectives of the projects?
In terms of education: We started with the idea of alternative education to get the students out of the studio and into the real world. And to do it in a place where students can use their skill to make a difference. Hands-on approach to teaching.

Social impact: Alternative education that is not arbitrary.

Lessons learned:
From the start we slotted in with an NGO that had been part of the community for a while. Therefore, the social aspects of the relationship between us and the community was already there, then we added architecture to that. We did not have to set the scene, establish relationship etc., which made it easier to slot in. With the subsequent projects we decided that we will always slot into projects where there are facilitating NGO's already in place. We ask the NGO's and the community whether there are any needs that can be met architecturally, and then we see if we can meet these needs within our syllabus.

Nature of the project:
Developmental

Contributors:
Other departments: Service learning department, Interior Design
Other SA universities: Conversations with UCT
International Universities: Conversations with Belgium
Local Communities: Co-design with community (community representatives)
Government: Only in terms of funding
Businesses: Sponsorships, discounts, products, Engineering assistance, free occupational health and safety work
NGO's: CORC (2012-2014) ; VPUU

* We have decided to never work with one NGO for too long. Else you get caught up in their ways of doing things.

Funding:
NRF, VPUU, Faculty funding, Research and development funding

University contributions:
Funding, student resources, our research capacity

Budget:
Between R 100 000 and R1 million

What have been the critical inputs into the innovation process, and who has delivered these inouts?
(1) We as the drivers of the projects
(2) Research interests of the two project co-ordinators
(3) The students design and work, their enthusiasm and willingness to do this.

Innovation been tested?
We did some research, were inspired by a project called Rural Studio in rural Alabama, and they did these kind of projects. We then just started, there was no test or pilot.

Technological innovation:
Technological sophistication has gone up quite a lot towards the more recent projects. A Technology lecturer drove the latest project. We have started using off-shuttered concrete, custom made steel brackets. We are building our own capacity.

Challenges
Time, focus and funding
We need to be able to operate like contractor. For example drive from the site to a hardware store and buy what we need. But University systems are not designed for that. We have to get 3 quotes for everything. Our next step is to not work with university but an institution with more autonomy.

Student involvement:
Design, build prototypes and participate in building. Go to site to co-design with community.

Community involvement:
Inputs and feedback on design. Not necessarily involved in the building process.

Outcomes:
(1) St Michaels School: 3 interventions (Built a gathering space under a roof)
(2) Vygieskraal: Shack re-blocking
(3) Southerland: Design
(4) Lwazi Park: Live project
(5) Lighthouse project: Technological design and built
(6) Lotus Park: Water platform and shade for netball court

How many people are using the innovation?
(1) School: 250 children
(2) Xoma: Family
(3) The others we do not have data on the amount of people using it.

Critical factors in people's decisions to use the innovation?
(1) Convenience
(2) Whether it meets existing needs

What are you aiming for?
(1) Adding utility to the environment, building things that are actually contributing to the community.
(2) Teaching students: Putting them in a different context to where they normally are; Letting them respond to an actual need, and go through the whole process of design and implementation.

Recorded any quantitative/qualitative?
After the first project we went back for observation 3 times, we noticed that the structures weared quickly. We then took students back to do maintenance. From here we learned that the structures need to be more robust.
The projects have driven the curriculum to a more hands-on direction. We are looking to implement more such projects. We hope that they have the potential to change students' mind-sets.
We have started gathering 'qualitative' data from students regarding: how the introduction to projects like this, what they see the impact on practice being. Because it is difficult work to do commercially - it's not profitable.

What have the outcomes been for the university?
PhD's, Research publications, research presentations, R&D partnerships, Student education, Competencies
It created research networks
It supports the reputation of the department and the university

Most important principle of this work:
(1) Collaborative
(1) Situated in a specific real life context that influences it.

Critical decisions
(1) Working with the NGO's: Realising our limitations, realising that sustainability is crucial
(2) For the two project co-ordinators to start working thither

Institutional embeddedness:
Platform-based

Degree of new technology:
Incremental

Dominant university mission:
All three equally

Describe the innovation
Process based innovation.

(1) The context is innovation
(2) Collaborative approach
(3) The design build work: This is innovative for our university.
(4) Eco-friendly technologies: recycling; earth technology; frame structures

Project A2

Interview date: Monday 22 August 2016

When did the project start
My intro to service learning was at Stellenbosch University (2013). Round about 2012 Slum Dwellers International (SDI) approached the university and asked if we would be interested in getting involved in re-blocking. Then we thought about it and did not come on board immediately, but what we did was we had a planning practitioner who was interested in using our students in this sort of idea of re-blocking, because he was involved with a government contract and wanted to use our students. So we said, we don't mind but it will be a volunteer thing, it won't be part of the course/curriculum. And students could only go if they wanted to. So there were 5 B.Tech students that volunteered. They went out and they did mapping using technologies such as GIS, GPS. They went but it was not managed very well. They had to find their own lunch, they had to find their own way there, sometimes they arrived there and there was no-one there. The students became despondent and they pulled out, which was a bit inconvenient for the practitioner.

And then I thought this looks interesting so I went back to Addie at SDI and said that we want to get involved. He said that they have got a few projects that have been approved by the City, re-blocking projects. And the idea is that the community gets re-blocked so that they can have services put in there, and there was one in an industrial area in Cape Town and asked if we would like to get involved. And what it i, it is in an industrial area, and it's a public open space so it is a small site. All the vagrants in the area were asked to squat there by the municipality for convenience and it grew into a substantial squatter camp. The municipality agreed that this needed to be upgraded and services provided because they had two water taps for 90 families, chemical toilets etc. This was a project that SDI was given. Now in order for the City to approve a project like that they have to get commitment from the community, and the commitment is that they start a savings fund. So SDI went to the community and started this. A lot of the times its the woman that do it. And everyone had to buy in and start a savings fund and when they get to a certain amount of money that they have collected, the City comes on board. So this happened. When we got involved with the project they had a savings fund and now the first phase of these projects (the whole project outline was done by SDI) is to first do community mapping, mapping and enumeration. SDI has got this slogan "when in doubt count". They started with the community doing a community map. It was a great map but it has no scale, not geo-referenced in any way but it is very accurate. They selected someone in the community to do it - there are some very, a lot of these people are vagrants that have fallen out of society but are very clever people that have been involved in industry. So there was one person that was willing to assist.

There is also another organisation called Informal Settlement Network (ISN) which is a network of people from communities that have been upgraded, then they go to the next community and they assist. And then when that is upgraded they go on. So what you get is people from another community coming here, advising them how to go about doing this. So you have got SDI, ISN and then there is CORC (Community Organisation Research Centre). ISN was involved in this project, the people who came here were previously involved in Milnerton, it was a very successful one. ISN's role was to assist the community here to set up a savings fund and to start doing this mapping. They managed the process. So it was easy for us because we had buy in from the community so we did not have to negotiate with the community at all. We simply were invited by the community, ISN.

We then went in there with our technology. First of all, we used aerial photography, satellite imagery. Students did a digitising map from this and that was the first step. So they had not been to the community they just did it in the classroom and we came up with the amount of shacks there and a plan. It did not correlate to the one drawn up by community at all. When we went back and did it on the ground we discovered that this method of mapping was absolutely unacceptable. So then we said the students must go do it practically in the field using measuring equipment like GIS and survey equipment and tape measure. So then we came up with a 3D drawing. This drawing represents the drawing done by community member, the only difference is that spatially it was correct. And we put this map up in the community and they could identify their shack and we had enumeration data attached to each shack. so it had their name whether they were employed, nr of children. They could then comment and say if things were incorrect or missing so there was participation here. So we corrected it as the community gave feedback. Some of them did not know how to read a map so they asked their friends or us and suddenly we saw social capital developing here. People started getting into groups and participating. Before only the community leaders started participating now even the poorest of the poor started participating and also once everyone was happy this was the first time that these people had any recognition that they live there. And therefor suddenly they were prepared to do whatever we asked. We were saying to them you are going to break down your shacks and rebuild them in a different place, in the beginning they said no but after this map we got buy in. Because they had some sort of tenure, they were identified in the community, they felt that they belonged there. What you do in re-blocking is that if they have a large shack you replace it with a large shack. Which is something that they worry about - that you are going to kick them out and give them a little hole. They also have the opportunity to say where they want to move their shacks too. The whole thing of social capital, of them seeing their names on that board, some of them told us you have measured it wrong, this courtyard belongs to me - so there was really participation.

The students in the lab did a new layout for the community according to their learning in other words they did a proper planned layout with access and everything. We plotted it to scale and each shack was cut out with cardboard and numbered. Then we met with the community and then each group from the community came there and were able to push their shacks if they wanted to live somewhere

else. This layout was community led. We then just re-structured a bit for practicality. We then came up with a final plan. It went from as-built to what the students suggested to how the community pushed their shacks around to ultimately constructing an acceptable plan. It was approved by the city and then they (city with assistance from community) demolished the shacks. It was done within the community, they never had to leave. Then the community themselves re-built the shacks.

Now when we say savings scheme (how does a vagrant save money if unemployed etc.); when they participated in this process they got paid (by the city) and it went into their savings fund. SDI was involved in determining how much they got paid etc. SDI has been very successful with this model of minimalistic institute (no-one moves) upgrade.

There were certain things that SDI paid for. In this project SDI paid for the materials which is not ideal because you want it to be sustainable, you don't want huge money input. You want the community to contribute. So it was a bit of a subsidy by SDI but it should not be like that, the community should save enough money to buy the materials to build their shacks because then they own it.

The role of the city?
The city provides funds (2.6 mil) for the cost of putting in services. At the end of this each person had a shack that was fire resistant, a flushing toilet with a tap with fresh water that drains away. All the roads paved and relevelled so that there is no flooding and electricity. This was paid for by the city.

Why did it need to be re-build?
What happens is that the municipality cannot put services into the community because it just developed informally like this. So they need it in rows so that they can get emergency vehicles in, and that they can put storage and storm water and regrade it so that it doesn't flood. Re-blocking is when the community breaks down their shacks and re-builds it in a more organised fashion. In doing that remember that they started a savings scheme. So now they are going to get new material to build the shack that is fire and water resistant and built in a proper way. And they are going to own it. Because once they own 25% the municipality will subsidise it and that shack then becomes theirs.

How would you describe your role?
We had a triad partnership, it was a service provider (municipality), academia and the community. It was aproper memorandum of understanding signed between the community and academia. we never dealt directly with the service provider. We dealt with the community and empowered the community to deal with the service provider. So our role in this partnership was simply to facilitate knowledge transfer. To assist in creating that social capital to empower the community to be able to negotiate on their own behalf. **Was this something that you decided upfront or was it insight that emerged?** Our mission was simply to assist in the mapping process because SDI start with mapping and enumeration. They asked us to assist. The social aspect was not planned in the beginning. But now the projects that we go into are called 'community mapping'. Community mapping is not about a map its about going into the community and knocking doors and finding out who lives on the inside. You can easily map a community and describe it as it is, but there is no descriptive context. But it means nothing until you have got the abstract context. Finding out about the culture, what are the people's cognitive idea of the spatial layout of where they are.

The next project we are working on: we look at the 3 types of mapping, cognitive, community and participatory mapping. All these 3 contribute to the understanding of the community. It is a technical thing but the process of doing it is a communicative way of planning. And only once you understand the community can you actually plan properly. This mapping is just vehicle to get into the community. The longer the project goes on the quicker the community leaders start losing interest and then it's the other members that come forward, its normally the woman, the marginalised and the poorest of poor. In the beginning it's not easy to understand the community fully but the longer the project goes on the more you understand.

What was it that triggered the next step (moving away from volunteers)?
I come from a geomatics background. Surveying is what I do. In fact, the subjects that I lecture is GIS and Infrastructure and Services planning etc. And I managed to convince the department to buy a few mobile GIS units and I thought that this would be ideal for my students to get involved in primary data collection in an informal settlement especially with this beautifully structured thing that ISN and SDI came with, they were very helpful with easing us into this project. So that is how I got involved, it was a mapping exercise, that is what we were asked to do. To try and improve the layout so that it could be more useful. So the volunteer thing was out of our control. The students just went; it wasn't managed properly. The same with the UCT project - it was not managed close enough. The students were just sent out there, sometimes they did not come back for days, because they did not have transport and they got mixed up etc. ***Nick mentioned this project at UCT where a lecturer put together a very elaborate brief that was then presented to students but he was not involved himself in the actual process** - yes and it was integrated into the curriculum. It was planning and design studio which is a module in the Master's degree, so it was credit bearing and part of the curriculum. For me this is not studio, because in studio there are certain things that you have got to achieve and when you deal with communities you might not be able to go there for 18 months, and what happens to your module then? Whereas the way that we are doing it as a service learning component, then we can go somewhere else, we can go to another community, we are very flexible. So if you were to ask how do you manage this thing - yes it is extremely difficult if you timetable it - you can't. In fact, it happened at this community: Flamingo, for 18 months we couldn't go there because the City started withdrawing and did not have funds and nothing happened. It went into a sort of hibernation. Which you can expect, because you don't know how these communities are going to respond.

What does the service learning approach practically entail?
According to the Highers Education Act all universities have to participate more in community engagement. Therefore, all universities have to have a service learning component in their curriculum. To facilitate this universities, have units. The purpose of this unit os to

assist in setting up partnerships for service learning and community engagement. They encourage you to set up a project and they will nurture the partnerships - formally set up a memorandum of understanding and then they will actually fund transport and equipment if the project is approved. In order for it to be approved it has to be part of a module in your course - it has to be credit bearing. Students have to participate and they have to be assessed on that particular aspect. And how we assess it is through reflection. So one the students have been on sight they do a reflection.

I have used 1st,2nd and 3rd year students. I lecture a GIS course at third year level and I have attached the Flamingo project to that module. Part of their module is to go to Flamingo Crescent and participate in mapping. What we do is we simple go there and assist the community so we never really need any resources. A lot of projects fail because suddenly there is no more money. We never give anything accept we contribute a process - it's about going on site, getting community involved, creating the social capital, keeping the conversation going. We also teach the community because community mapping is about ultimately teaching the community to map themselves and then you can withdraw. **Why continue mapping?** When you re-block the community, you have to wonder whether they will be able to operate as an urban unit. We are interested in what happens to this community now? After re-blocking we went back and did an as-built mapping. Each shack now has an address. But what is going to happen now? Is it going to remain formal? Has the community been uplifted and will they continue to uplift? And in order to that we keep mapping. What we are doing is we go back there and we use a droan to see what is happening now. And if necessary we go back and knock on doors. And also we want to hear stories (cognitive mapping) we want to hear what they think about the change? Students go back to map. This is part of the course.

Timelines attached to course - how do you practically manage that?
The studio situation where students have to achieve a certain competency in order to pass won't work. This is only 10-15% of their mark. And if we cannot go into Flamingo for some reason like riots - then we just go to a different community. It is just an experience going into the community, it doesn't matter where.

Also the timetable at the department has to be very flexible. I am running two service learning projects that are not on my timetable. Sometimes I steel time from other lecture time. We have that agreement and without that you probably could not do it. So this department is very tolerant to these community things. It is a flexible thing within the department.

Another thing that I do is that I never take more that 5-12 students at a time. I am going ou there twice a week. We always wear bibs so that the community is not suspicious. In the beginning when we went to the community they were never there - always disappeared into their houses. After 3 months I have never seen so many people in that place because they were just continuing as normal. We became a normal thing every week - they were not scared or intimidated, they were happy, we gained their trust. We have got certain projects that we are taking in students but the course is not specifically related to Flamingo. It is related to mapping.

To what extent would you say there is a knowledge sharing platform at CPUT - for example knowledge sharing with [redacted] at Architecture Department [redacted]?
We are desperately trying to do multi-disciplinary, trans-disciplinary projects because we don't want to operate in these silos. And that is what you are getting. You are getting people like architecture doing their re-blocking and we are doing ours and that is not on at all. The project after this which is a mission station in Picketberg, we doing a project there, community mapping. It is very different because it is not an informal settlement. We did it with the engineers, we had quantity surveyors from the engineering faculty coming out there with planning students from informatics and design, doing the same mapping exercise. It was very interesting because the engineers are solving the same problems but they are looking at it in a totally different way, but it is assisting the planning students becasue they didn't realise that those engineering aspects are so important to the community. The engineers didn't realise the social capital and the social impact of what they are doing in this community. So we have done few projects with architecture, we have not benefited completely from each other's projects, that is something that we still have to bridge. And that is what the service planning unit is trying to do.

We have got emergency service, town planning, architecture involved in one upcoming project in Paternoster called Jazz on the Rocks. So we are moving towards trans-disciplinary.

So what is the role of the service learning unit in that and to what extent is it individuals in the departments who find each other?
The university is getting quite strict in that every department has to participate in service learning. In order to be able to get accredited with a service learning module it has to be registered with the service learning unit. So all faculties and departments are going through there. We get to meet everyone in the university that are participating in service learning and engagement. And there is the opportunity to get on board.

Another project we did was a centre at Boys Town. They have asked the university to get involved. Architecture and Town Planning went there and did a little mapping exercise. It was just the morning; we took the students there for one day.

Each faculty has a service learning co-ordinator. I go to my co-ordinator with a project, he then goes to the Service Learning unit and gets it approved.

Where does these projects like Boys Town come in, how do you guys find each other?
That particular one came from Stellenbosch University. These things happen through departments, through service learning. It is not ideal. I was talking about these three models: The one that UCT uses is called the 'shopfront' model. What they do is the community approaches the university through their service learning unit and says that we want assistance from the university in something. Then

the university tells all the departments and faculties to come up with proposals and they put them up and then the communities comes and chooses the ones that they want. The community therefore identifies what sort of assistance they want. Then the other model is where you have the service learning unit, collecting the projects and then they delegate these projects to certain departments and faculties as they see fit. So it is no longer in the hands of the community it is in the control of the service learning unit. The third is the one that we are using where you just have hap hazard projects and that's where you have architecture doing one. They have done some very interesting ones that I would like to get involved with but that did not happen. My way of community mapping - I think they can make use of. Architecture has got project called The Sandbag Housing. They build houses out of sand. But the resources needed and the effort involved, we have not got the capability at CPUT, departments doesn't do that. It's not about community service it's about community engagement. People get mixed up. It's not habitat for humanity, knowledge transfer, that is what we do. Social capital is what we achieve. Yes, you can go on and do these sandbag houses but first you have to go in and do this mapping. And it's not about the map, it's about getting to know the community. In this faculty we have got IT, we have got jewellery design, now how do they get involved. They can come do mapping, they can assist the community in getting the map done and then they can get the whole idea of how these communities are living and it might reflect in their design of jewellery or systems and apps. Anyone can map. If you have got the right people with you. In the Teaching faculty, they were also quite interested in just joining us for this mapping thing. Ours is very sustainable because we don't need any money we just need transport. And we will use our equipment.

We won a ward for Flamingo in Geneva. I have been to a few conferences and I presented this in Geneva at the Geo Spatial World Forum. They were blown away and said I must apply for an award. The next conference was in Lisbon and I was presented with this award for excellence for the use of geo-spatial in a project.

Would you call this project innovative and what particular will be innovative?
It is innovative because when you go with the students. I have got to lead and the students follow, this business of sending students in doesn't work, they have got to watch the practitioner and learn. But what you get is action research. There are things that you don't realise you are going to do or need to do until you are there - its action research. I have done a lot of conference papers concerning my experience doing these projects. Innovation as well is for instance how can mapping be used to assist communities that are so poor and uneducated - how can mapping assist? And I think what the geo-spatial crowd was so impressed with, is how do you use this which is a very rational comprehensive profession - surveying. How do you apply social aspects to mapping? And this is it, through community mapping, through cognitive mapping. GIS is about things that are accurate in relation to one another thing. That is very rational, how do you make that fuzzy. Through attribute data which is not necessarily spatially referenced but the opinion that someone has on some spatial pattern for instance. That is the innovation - you use this mapping technology in a social context.

So SDI had the process, and the university did the mapping. What is the term community mapping?
It is a concept described in literature. It is quite new. It is when you go into the community and assist the community to map themselves and ultimately the goal is t continue mapping themselves. Participatory GIS is when you go and map in a community, but you map with the community but you are going to take the data away and they are not going to deal with it. Then you get GIS which is a quantitative way of mapping, which can have attributes that reflect the abstract context. And then of course you get crowd sourcing, you sit in your office and receive a message that someone had committed a crime at this location, you then add it to your map. the community provides the info and you manage it, the community benefits because you do a spatial analysis and provide solutions for specific problem areas.

SDI are definitely the architects of the process of re-blocking where you start with mapping, that is their idea. Savings, Mapping and enumeration, community lead layouts, re-blocking and re-buidling with service delivery. We still have contact with SDI, Addie our main contact left. But one of our ex-students started working for Corc and he has been involved in this project.

Outputs of Flamingo for university?
Conferences, students who get their credits, getting an award at international conference was good exposure for the university. Our university website wrote an article which everyone at the university sees. The service learning unit has certain reports, a successful project like this would be an attribute for them. No journal articles as yet.

The students most certainly get that experience, they have to participate in a reflection, they also get a certificate that they can put in their CV's. And this is an absolute essential for any planner is that it is a communicative process, you have to go out there. I presented in Planning Africa Conference in July where we discussed this radical type of planning, this bottom-up vs top-down. This community mapping is also of interest to the profession in that it is a true way of public participation. And this bottom-up approach doesn't go well with planners because planners normally intervene at a top-down level. And bottom-up is not always useful. But Sanda Cock is an American planner that calls this Radical Planning. Rather than communicative planning. The academics at UCT are also very good, Vanessa Watson (bottom-up planning academic).

After a re-blocking, to what extent do you track impact?
Its newly done, so we have been back once post re-blocking. It is interesting it's not Utopia. You go out there and think that they will be mapping but they are not. You go there and its dirty and you ask why and the community leaders say that they told them to keep it clean but they don't. We have not been back this year because of elections. The HOD decided not to allow us back. But we will go back, we are busy purchasing a drone. We have not flown it yet but we will use that technology to keep monitoring the community.

The one time I went back, I felt that they were tired of us. They were very structured and organised when we came, they met us and there was always a monitor with us and all the rest of ist. The time we went they were a bit annoyed because the time was up and etc. I got the sense that now that they had the services they were tired of having these meetings. But that is where we have to go in discretely,

and not bother them perhaps with the drone. and at some stages through the NGO arrange to come in. But we don't want to abuse - just because our students have to go there. So we are giving them a bit of a break. The NGO has also moved off a bit.

We have moved on to several other projects like Jazz on the Rocks. It is an amazing event, but the fishing community has to get involved. We got some unemployed youths, brought them here and trained them in map reading. They participated in the festival as monitors and we were hoping that they could help us again next year but they all got employed. They got certificates and huge exposure because of this mapping.

What is your role i.t.o continuity?
My research is all about how important this mapping is. The argument is that you cannot just use the descriptive context you have to use the abstract context.

I pro-actively approach other departments, for example Mechanical Engineering want to bring hydroponics into communities, but I know how to approach the community. The service learning unit has started realising that this is an option and will suggest to get me involved because of this mapping. It's a concept that I think anyone can use to understand informal settlements and poverty and that sort of thing.

There is hardly any funding needed, so what are the key factors in the success of these projects?
The reciprocal learning, because we are Academia, the advantage for the students is to go into these communities and understand what they are dealing with. Because that's what planners do. If you can go into these areas - it's essential for these young planners of today to be able to go into informal settlements.

For the community it is an essential thing that you empower them so that they can tell the service provider what they need instead of the service provider telling them. For them to say there are families here 90 families here, the community can say no there are 700 families here and for them to be able to negotiate for themselves. I think any community that is negotiating for services and have an issue with land tenure can benefit from the university's input in doing this mapping. Maybe it is nt that they want to be able to map themselves but certainly with this assistance from the university they will be in a better position to negotiate.

Anything we do goes straight to the community. We don't take ownership of everything that we get.

To what extent is this about student's education and to what extent community development?

It is definitely mixed. All in. This reciprocal knowledge transfer, not only that it is the students that passes on knowledge to the community, the community passes on tacit, indigenous knowledge back to the students, but the academic is also involved with research. Nowadays in academia you can't do these three separately, my teaching is my research. the students learning is part of community engagement; the community is benefiting as a requirement of the Higher Education Act from Academia. So it is a mixed thing. It is a multi-disciplinary. It is academic community engagement and the vehicle being used to engage with communities is service learning. The researcher is gaining research output from this and gaining that mode 2 knowledge rather than this mode 1 knowledge all the time and this action research. This business of writing academic knowledge is in the past we have got to have mode 2 knowledge. (mode 1: codified, mode 2: tacit). Gibbins and Hall write a lot about this.

Project B1

Interview date: Tuesday 23 May 2016

When did the project start?
The idea for the co-operation started in 1995 from one of my colleagues at the University, but it never got off the ground. In 2002 we got involved from the University and we began to set-up the co-operation, to register it and set up a bank account etc. The funding from DST was only received in 2004.

What was your role?
I was the project leader. CEO of the cooperation

How would you describe the nature of the project?

We aimed to eventually be for profit, but was dependent on funds from DST. I would say Mix of for profit and non-profit cooperative.

Who was involved?
NGO's:
There were NGO's who provided finances and services.
Swiss Contact: Funding
Woord en Daad: Provided a loan for the infrastructure of the cages.

Service Providers
And there were also service providers involved that helped with training, but we had to pay them.

Ethical Leadership Institute (ELI) that provided training

International Universities
UISAD Program called farmer-to-farmer program. It is administrated through a university in Florida, called Agricultural and Mechanical University. We had to make a short list of our needs regarding training - for example we needed an expert to train us on fish diseases. Then we would put it on our list, then this university in Florida would identify individuals with this knowledge and ask them if they would be willing to come to SA for 3 weeks to give training, and the University from Florida paid for everything (flight, accommodation, salary etc.). I think in the end they sent 12 experts over 3 years. The next year we reapplied for the project, but that year we did not fly in experts - we made a training DVD. Then the University of Florida hired cameramen and a director and made the DVD. It specifically focuses on responsible feeding management.

Government:
Winelands District Municipality gave us a R300 000 grant one year. This was used to buy some of the equipment. They were not involved in any other way.

Project Budget?
The funds came from Department of Science and Technology. R 900 000 per annum, for the first 3 years. Then R4.1million per annum, for the next 3 years. Cape Winelands Municipality also provided a grant of R300 000 one year which was used to buy equipment. Therefore, budget definitely between R 1 - 10 mil.

What have been the critical inputs?
The technical training and we helped with site selections.

How did you evaluate the projects?
We have a questionnaire that each farmer must complete before he can re-apply for operational capital. [Copy of questionnaire has been provided] The questionnaire contained both technical and qualitative information.

How did you originally identify a prospective farmer?
There was no specific rule. We looked for dams that would be suitable. But news of this project spread by word of mouth, so many times the farms would contact us and asked if they could participate. On the farms themselves there is also a lot of pressure to apply black economic empowerment, but farmers and businesses do not want to give up their land - so this was actually an ideal project that enabled them to apply BBBE on their farms, without losing any of their land.

There were also other farm workers who heard about the project from other farm workers. It differed from farm to farm. Normally I would first meet the farm manager or owner and tell them about the project - give a presentation. Then he would for example say, he likes the project and he would like us to come and give a presentation to the farm workers one evening after hours. Some farmers made the decisions themselves, for example selecting all their supervisors to partake in a one-year pilot. Other farmers would say everyone has to participate or we leave it. Others would say that I should come do the presentation, then he will put a list up and people will have 2 weeks' time to decide whether they want to participate or not. If they wanted to participate they had write up their names and pay R100ou of their own pockets to get that commitment. The largest project was about 45 farm workers on one farm, but this was also the one that did the worst. Nobody took responsibility.

Noticed any best trends to suggest to farmers?
Yes, we realised that small groups work better than larger groups. It also works better if there is a farm manager involved. He/she does not necessarily have to share in the profit, but he must own shares. For example, if a decision has to be made, he must have a say and a vote.

Where was the technology developed?
It was developed in Stellenbosch, Jonkershoek. We built the cages and learned and brought about changes. The feed was also developed by us. The project in Jonkershoek started in 1989, so it took 15 years to develop the technology and feed before it was implemented in 2004.

How many people used the innovation?
We built 30 of these cages. About 300 people were trained and about 500 people used or were involved in these farms.

Critical factors in people's decision to use the innovation?
Many of the farm workers were sceptical, because they did not know anything about salmon farming. But once the project was successful on some farms, we could take people and show them how it works. One must also take into consideration that these farm workers are people who never make their own decisions, they are always told what to do. So to be involved in such a project gives them status and makes them feel important, I think this also played a big role.

What are you aiming for with this innovation?
To provide a second income for farm workers and the socio economic development of farm workers.

Any qualitative or qualitative performance data recorder?
See reports provided

What have been the outcomes so far?
30 cages were implemented, 300 farm workers were trained, and 500 farm workers were involved.

Were there any students involved?
Students were involved, they did seminars and two students who worked on water quality also participated, one did honours and the other master's degrees.

Which decisions and choices in the innovation process have been critical in terms of its outcomes?
- Training
- Extensive business support from US (partnership)
- Market demand for the product - the fact that the initiative was driven by actual market demand.
- Professional input was very important
- Subsidies

Outcomes for the university:
The two water quality students published some of their work. There were not really any scientific articles published about the project. There were talks at conferences.

Could you please describe why the project failed?
The problem was with money, cash flow. When we received the money from DST there was always a large pool of money, so if 2/3 project failed in a year the co-operation wrote it off. But the co-op could only do this because it received money from the government, so this money could be used to pay off the farmer's accounts and to clear their loans. But the year that the government did not supply the funds anymore, there was no money pool anymore. Then when some farmers made a loss, the co-op did not know how to handle it and what they did is they kept the profit of the projects that did generate profits in order to pay off the debt of those who made a loss. And this caused a cash-flow problem.

This caused a lot of friction. One consultant from an NGO started creating more friction by telling the co-op that it is the university's fault. That the university is providing the wrong training and that they are applying for the money and then they use it for different projects etc.
The co-op then held a board meeting and then they decided that they would rather continue on their own and not work with the university anymore.

Project B2

Interview date: Tuesday 17 May 2016

Some background
The company was formed to execute a particular project. The project under discussions is sponsored by the department of Science and Technology and it is administered by The Water Research Commission. It os not primarily a research project it is supposed to be an implementation project. So basically the technology was at a particular level and this project aimed to finalise the development of that technology and implement it. We felt that the best way to do that will be via setting up a commercial entity that could take that further. That is how Vulamanz came about.

There are two parts to the technology. (1) The filtration which removes 99% of the bacteria. (2) The user adds 3 drops of chlorine to the product container. - Reason for chlorine: There have been various studies that show that even when a user is receiving safe water people were still getting ill, part of the reasons for that is that containers and implements that people were using were infected in the first place.

When did the project start?
The DST project was granted in 2014, so it was towards the end 2014 to 2015 that there was a significant focus towards setting up this entity that would take the project further.

Your role in the project?
Project leader
Initially the project started with 3 members. Myself, from Durban University of Technology (DUT) at the time, a colleague from DUT and an ex student who was from UJ.

Then after forming [redacted] with Innovus, more people became involved. [redacted] was brought on as project manager to handle all the logistics of the project.

Main objectives
To develop and demonstrate a technology for rural water treatment.

There are various water treatment devices available. Some have been successfully taken up by communities, but many of them have not been successfully taken up. So we started off in reverse looking at what the particular reasons were behind why these units have not been taken up previously.

The students involved came from rural communities. One of the students came from a town in the Eastern Cape shot down a lot of the ideas that I had at the time. He knew that it would never work in such a community. So there has been a lot of input from the students involved who came from these backgrounds and guided us on where we should be heading. Along the line there were probably 7-8 students from rural communities involved in this project.

Who has contributed?
This particular version of the technology (focusing on drinking water for rural areas) started when I was at DUT. There were 3 partners involved: Savanna State University (Georgia), Asian Institute of Technology (Thailand). We worked closely together and got the technology up to a particular level and then it got stuck because significant funding would be required to take it up to take it on to the next step. For two years nothing really happened on that. During this time, I moved to SU. Then when this project became available - that provided the funding for us to actually do the final development. The technology has been around for about 6 years and then for 2 years there was no progress because we did not have the funding to continue.

Funding
All of the development previously was funded by the Water Research commission. But we also had some funding from US-Aid (This funding did not come directly from them they funded Savannah State University who then funded the project).
Amgeni water also put in some funding (the large water utility in Durban).

Critical factors in people's decisions to use this product
1. Fit with daily lifestyle: If you introduce a new technology that requires a very fundamental change in the way in which people do things - they are unlikely to pursuit that. For example, units that require significant amounts of cleaning per day etc. are not likely to be abandoned down the line. The unit that we developed

[Process: Normally a person would go down to a river or stream, and carry back up a 20-25 litre bucket of water. They would have that in the kitchen and use it. So the only difference with the unit we developed sd that when they get back to the kitchen they pore it inti this device. And then when they do collect the product they hava to add a couple of drops of chlorine to it.]

2. Perceived value: One of the major problems is that many people in rural communities are not actually convinced that there is a problem with the water in the first place. They believe that because the generations before them drinked the water and was fine they can also drink it. If people are not convinced that there is a problem, it is a challenge to try and convince them to do something extra when they don't see a value in it. Generally, the females see the value in it because they are the ones that have to deal with sick children etc.

Within 3 weeks of initial installations: There was one grandmother that had to take her child to the clininc every week for drips. And 3 weeks after the instillation she no longer had to take the child because he/she did not get sick. She is completely convinced that it is because of the water, we cannot scientifically prove this though. But sheis convinced and she has also convinced her neighbours. Therefore, if there is a perceived value to the product, people will sustainably use it.

Nature of the Project
It is an R&D to final implementation project. We aim for it to be commercial.

The whole idea is that the technology was thoroughly investigated in the laboratory. And then you develop the product that works scientifically. Now we need to take the product and turn it into something that can actually be put out into the field. Then there are issues like robustness and ease of use and all this are being solved. The application is developmental but the fabrication of the product is to be profitable.

In SA the government is obliged, according to the constitution, to provide people with water. Except at present there are no technologies to do that. So what we are expecting is that the final product, when mass produced, relatively inexpensively will be implemented by municipalities. The user in SA is unlikely to pay for the device in view of the fact that they are promised water. In other parts of Africa etc. either the users would have to purchase it or an NGO would sponsor the installation.

People who have contributed

- No other departments
- International university: Savannah State University; Asian Institute of Technology
- Local community: Community gives feedback on design and what needs to change.
- Government: Capricorn district municipality have been very co-operative. They have given input in almost all the aspects of the project. For example - they helped with translations of training material, the servicing and maintaining of units will be sustained by them. The municipality also communicates with the traditional leaders, for example when we had to get people who would test the units their social person - approached the councillor, they together went to the queen, explained the project to her and her council and when they were happy with it they communicated to the community. There is a phenomenal amount of things that happen on the ground. And when you go in as an outsider I would expect that you are going to meet "blank faces".

Generally rural people are very conservative when someone they don't know shows up and makes promises the community knows that they are going to get ripped off.

- No businesses: Deliberately not involved any financial interest because of the issue that we want to commercialise the entire thing.
- No NGO's: We have been in contact with potential major users e.g. Red Cross and Path. But they raised the questions: has it been implemented in field and for how long. They want it to be tested. - Now at the end of this year we would have had 6 months' implementation period and together with that we would have to have a commercial entity that could mass produce the units - at that stage we will start approaching NGO's as clients with results of the field trials.

Challenges and how you overcame them?
When you are sitting at the laboratory level, you need money to take it to the field, but you won't get that money until you take it to the field. Normally you would have to bring in an investor and rural water is not regarded as the top investment, hence the DST project made the critical difference. Now at the end of this year we would have had 6 months' implementation period and together with that we would have to have a commercial entity that could mass produce the units - at that stage we will start approaching NGO's as clients.

University contribution
Most of the innovation was already done prior to my coming to SU. The university was not very actively involved. But this is simply historical. We did however have a relationship with SU Polymer Science department going back many yeas ago. The early development of this technology [redacted] from polymer science was strongly involved. [redacted] capillary ultra filters and at that stage we actually attempted to start a company to commercialise that also called [redacted]. But it did not succeed. The first technology we worked on was the capillaries that he developed and then we started working on this woven fabric technology for different purposes. And this was the earlier version of what led to this drinking water project. Innovus (Tech Transfer office) have been extremely helpful in terms of the management of Vulamanz. The project manager was appointed by Innovus and he is doing a phenomenal job of it. Innovus takes care of all the administration etc.

Project Budget
Between 1 million and 10 million.

Critical Inputs
The inputs obtained from students who came from rural areas, because that knowledge does not appear in journals. You can go read up on a particular technology, but this input you just can't get. So the input from the people on the ground was a critical thing.

Testing?
Scientific testing: CSIR has done extensive evaluation of the system. So we know that the system works - if there is a problem it is going to be with a particular unit.
Results: The main indicator we are interested in is E. coli. If there is E. coli n the water it indicates fecal contamination. So water must have zero E. coli. Normally in a bad river your E. coli would be in the 10's-100's. CSIR tested units with E. coli counts that were up to 300 000 and zero comes out of the system.

Testing in the field: 25 units have been implemented.
Capricorn Municipality are waiting for their municipal managers to sign a MOA and then 500 already fabricated units are ready to be implemented.

Surveys: Surveys were conducted on 4 of these households to identify initial problems. (The units were installed in February and then end of March the survey was done).
Results - The people that were visited were all very positive. Especially the older woman.

Future test: We have drawn up a proper survey of user attitudes with the help of Social Scientists, this is being passed by the SU Ethics committee. This has not been implemented yet, at present they are working out the schedule as to how this is going to happen. Capricorn Municipality will be in charge of doing the survey. Their plan is to use high school students for these sort of things. Previously whenever they wanted something to be done in the community they used high school students. The surveys purely concern user attitudes. Parallel to that the municipality will do water quality analysis.
The municipality has to go through the traditional route in order to do the surveys.

Critical decisions and choices i.t.o outcomes and how?
All decisions related to the design, because the need, usability and fit with purpose all feed into the design.

What have been outcomes for university
7-8 Students

Couple of publications - mostly work is written up in the form of WRC final reports. But because we always intended for commercial application - we tended to be a bit quiet on the publications side.

Future outcomes: (1) If this goes well, SU gets regarded as the developer of a technology that we think is going to have a major market. (2) The water field - SU is probably the only membrane technology 'centre' in SA terms of water treatment - this whole field can put SU on the map. It contributes strongly to community upliftment/sustainable development/green.

If [redacted] is successful in being profitable - that would attract more good students into this research field. Presently water is not a first choice in term of research, but if it is shown that this thing can be profitable we could attract good students.

We have taken a very conservative approach: We want to make sure that everything works 100% before making any claims.

Control Variables
Institutional Embeddedness: Stand-alone
Champion: Prof Pillay
Type of Innovation: Incremental
Dominant University mission: Finalisation of technology - final development and implementation

Project B3

Interview date: Tuesday 23 May 2016

How would you describe the nature of the project?
Not commercial, it was a community outreach project. It was a proposed policy project.

Who besides you/your department, has contributed to the project?
Other departments: Department of Educational Phycology
Government: Western Cape Department of Education -department of special education
Local Community: 3 schools in Stellenbosch

What were the university contribution?
Research capacity, the name of the University and the fact that I have the time to do these kinds of things.

Project Budget?
Less than R10 000. I used some of my existing research funds to buy some of the Mp3 devices.

Some project requirements: We had to identify a Mp3 player, that was cheap, easy to use and that the children's would not want to steal.

What have been the critical inputs to the innovation process?
While my children were in school. I observed that the systems in place to help children with learning disabilities were ineffective. First, psychologically, the children were taken out of their classes and they were shy because someone had to read for them. Plus, it was a logistic nightmare for the person who had to organise it.

I got the idea that iPods should be used. One of the first things that came up was security - who is going to load the info on the iPods, and how do you make sure that the test is not leaked e.g. I then drafted a set of security rules for example using cheap equipment that is kept at the school. The teacher/anyone records the test onto the device and it is then kept in the safe until the day of the test. Some of the richer schools told the parents to buy iPods, which were then taken in and kept at the school.

Has the innovation been tested?
We tested it at one school at a time. 3 schools in Stellenbosch. Started at Stellenbosch High School. We tested it with a few non-critical occasions like small class tests. We got some feedback about finger problems while using the mP3's. Then we expanded to testing it at Rhenish and Paul Roos. I then contacted the Western Cape Department of Education and we started discussing the possibility of it being accepted in matric end exams.

The Department said that they would accept it if they received a request from the schools. I did not take it any further than the initial pilot. I then gave the project over to the schools.

What are the critical factors in people's decisions to use the innovation?
From a psychological point of view: It gives the child anonymity, technology in schools is something that other children are jealous of rather than a crutch, the child can stay in the class which was good because the child no longer felt alienated, but also because previously it was a problem if the child had to be in a different room and had a question that they would like to ask the teacher.

It also made the teachers jobs a lot easier.

Quantitative and Qualitative data collected?
Feedback: One school gave negative feedback, the teacher commented that one parent refused to allow their child to use the iPod. The school made use of students to read to the children, and it seemed as if though the readers did help with answers, and once the iPods were use the child did not get answers anymore so his marks went down.

None of the other schools gave negative feedback, all of them preferred the Mp3's to a reader.

There was some 'finger trouble'. Some of the schools did not properly explain how to use the devices, and then they struggled to use it.

What were the University Outcomes?
Unfortunately, there were no publications. It was a project combined between my department and the department of Education Phycology. I was in charge of the quantitative questionnaires, but unfortunately the qualitative aspect from the other department never left the ground.

What constitutes success?
From community outreach perspective: it was successful in the sense that it worked, and it made some people's lives better.
Research perspective: Not successful because there were no publications.

Institutional embeddedness?
It was a standalone project that I conducted on my own time. But could use some research funding and did collaborate with other departments at the University.

Project B4

Interview date: Tuesday 23 May 2016

When did the project start?
Cannot remember when the project started, we published an article on it in 2010.

What was your role in the project?
I thought of the plan, and the implementation of it - the programming work was done by a Masters student. I supervised the project.

What are the main objectives of the project?

How would you describe the nature of the project?
It was a prototype

Who, besides you have contributed to the project?
Local communities: only one local school

University contribution?
Developed the game engine, implemented it and gathered feedback.

Some background?
The Masters student made a game engine. Which was a framework on which a teacher could easily define their own games. You get educational games, but they cannot be changed, improved, expanded - if it was written for grade 1 maths, you cannot use it for grade 2 maths. So the game engine allowed the teacher to make other games, without having any knowledge of programming.

In the beginning, we approached a teacher and asked what she would like to be able to do with the game engine, what would work for her. So we made it, implemented it in the school and we got feedback.

Project Budget?
No budget, pure research project.

How long was the game engine tested/implemented at the school?
We implemented the game engine. It was used at the school for about two years, but the teacher at the school who was involved in this project left the school and then it was no longer used.

I visited the school at times to make some observations. The games were meant to be fun, but I saw that the assistants would sit with the child and tell them what to type in, which took the fun out of the games.

How many people used the innovation?
It was a school for children with learning disabilities. The game engine was used by one teacher and two assistants.

What are the critical factors in people's decisions to use this innovation?

The teacher enjoyed being able to tell us what she wants in the game. Commercial program material is not changeable. I visited many schools and the biggest complaint teachers had about educational software was that they could not change it according to their own needs.

Are any quantitative or qualitative performance data recorded? If so, what?
Trivial questionnaire for the teacher. It was basically asking what worked and what did the children struggle with, simply from her observation while the children used the game. Here and there we discovered some things that we did not think of from a technical perspective. For example, the children struggled to use the computer mouse. These were children with learning disabilities so they had both fine and rough motoric problems sometimes. Then we used a different type of mouse that had a large red ball on it that was easier to use.

It was a very simplistic questionnaire constructed from a computer science point of view, rather than from an educational point of view. It contained questions such as how many of the children liked the game and how many didn't. But after visiting the class and making some observations myself, I could see why some children wouldn't like it, because they were given the answers. Therefore, the questionnaire did not really provide any new insights.

How was the game used in the class?
The teacher used the game to reward the children. If you finished your work, you could go play the game. In order to move on in the game, the child had to answer a question correct.

What was the success of the project?
The interesting part for us was that we could code a game engine and that we could put a game on top of that, that a teacher with no programming knowledge could use to build a new game. From that point of view, the system was successful, but there was a large gap between the capabilities of the system and what the teacher felt comfortable with to do. The game was underutilised. They only used the games that we built. We made one for language and one for math. The children played with the existing two models, the teacher never expanded the games.

In your opinion which decisions/choices have been critical in the innovation process have been critical in terms of its outcomes and how?
Two answers to that question. The technology and the use of the technology.

In the technology: It was designed as an open system, which addressed a problem that was really an issue which teachers experienced. I conducted user case studies and found that the problems teachers have with educational software is that it does not change.

The use of technology: The gap between the teachers use of technology and our solution was however too big.

The system was very nice from a computer science perspective, but what the teachers actually want is to tell someone what they need and then that person writes the game. The step from them to be able to do it themselves takes too much time, if they are a bit uncomfortable with technology they are afraid that they might break something. So this step actually requires a middle man, someone at the school who is comfortable with using technology, who would set up the games according to the teacher's requirements. The prototype was developed, it works, but it is not part of my research to take it further. The gap between what id produced in a research area and what is usable in practice.

What have been the outcomes for the university?
National and International publications, One Master's degree.

At the international conference, a German from the Maxplank Institute from Fraunhoffer that asked if they could use the code. He was excited about how easy it is to make games on our system. They started using it, but they struggled with the code and I do not think it went any further.

Dominant University mission?
Research. My goal was community outreach, but for university it was research. Personally I feel I can only do community outreach if I define a research project out of it.

Project B5

Interview date: Tuesday 31 May 2016

Some background:

Few researchers came into [redacted] and found that there are problems with waste, electricity, sanitation. Then we brainstormed and started a few projects: [redacted] and many others. Then we realised we needed to formalise this in order to pay co-

researchers. So we started a voluntary association with our own bank account. Then the Sustainability Institute can also pay us easily in our account and we can use this money to pay co-researchers, operational costs and admin costs.

The research centre: Under this centre is the Sanitation, [redacted] etc. projects.

Start
Built and registered 2013: [redacted]

Role
Project chair-person, and built the centre

Objectives:
Informal settlement upgrading

Nature of the project:
Developmental

Who has contributed:
Other departments: Micro-biology, Engineering, Fine arts, Visual arts, Humanities, Conservation & Ecology
Other SA Universities: University of , UWC, UCT, UJ, Natal
International: Universities from Nairobi, Malawi, DURAM, Participea
Community: Enkanene, Langrug, Philipi, Hawik, Eastern Cape
Government: All - funding, subsidies
NGO's: Slum Dwellers int. , CDRA, COURC, ISN, FEDUP, Serve the city, Insite, WWF, Living lands, Wildlands, Legacy.
Businesses: Specialised Solar systems, Agama, Water Rhapsody, Pro-bio, HAPPIE, Phillips, Solarus, Khaya Power, Agrimark, Build-it.

University Contribution:
Researchers (NRF bursaries).

Project Budget:
About R27 million

Critical inputs into innovation process:
Knowledge and experience brought about by:
(1) Researchers
(2) Community co-researchers
(3) Supervisors
(4) Outside experts

Trans-disciplinary research approach.

Test?
We would start with 1/3 interventions. First by identifying people who would be willing to participate in this research, this is done through our co-researchers. Then approaching people and giving them the plans. Then we would start small e.g one solar system, one toilet. Based on feedback we would expand to 3. We conducted surveys and downloaded data from the system. The system measured actual watt usage

Then a pilot is set up. We then expand based on our budget. Expand through the process of incrementalism.

Qualitative, Quantitative:
Meter reading system: the amount of watts used
Non-meter system measurements: Payments, amount of times the system was turned on and off, energy consumed
Questionnaires asking whether people liked system/not.

Nr of people who use:
(1) 1000 solar systems installed
(2) 25 households that use the toilets
(3) 10 households use solar & water system
(4) 20 households that use [redacted] (Composting of organic waste)

About 1200 people use at least one of the innovations

Critical factors in people's decisions to use the innovation:
(1) Leveraging: People pay R100 for candles and paraffin to get light, we then countered with R100 for solar system. We had to look at what people already use, what they are willing to spend, and then suggest a new improved technology

(2) Meeting needs and convenience
(3) Hygienic reasons
(4) Comfort
(5) Security

Outcomes of the project:
(1) Strong relationship with co-researchers
(2) Amount of projects that have been implemented
(3) Amount of people that have services that they did not previously have
(4) Network has been enlarged
(5) NRF has started using Trans Disciplinary approach in their evaluations. They have embodied TD methodology as a result of this case study. They have identified [redacted] as their exemplar case study of community engagement through th methodology of TD.
(6) Capacity that is built in the community, in the researchers and the co-researchers

Challenging outcomes:
Some of the workers quit and were upset about payment
Resistance: Buildings were vandalised, a lot of damage

Outcomes for the University:
(1) 10 Masters projects
(2) 5 PhD's
(3) Research publications
(4) Hope Project
(5) Flagship project of Provincial Government
(6) Publications
(7) R&D Partnerships
(8) Patens
(9) Student education

Management:
Sustainability board of directors.
The project managers and supervisors

Knowledge transfer:
Developmental is a non-deterministic innovation pathway. Building capacity, co-learning.
As capacity grows the processes change, which is specific to context: organic bottom-up growth.
Training?

No, we don't have resources to train people. Learning-by-doing approach. We come here to learn. Researcher has academic knowledge and computer skills. Local person knows the dynamics, the politics and social. We merge this in co-production.

Co-researchers are hired on contract basis.

Critical decisions:
(1) Letting go of participants if they are no longer needed - contract based work
(2) The decision to build the research centre in [redacted]
(3) The types of solar systems used: We saw that with the meter system, people could see how much they consumed and used less electricity. We decided to take the meters out because from developmental perspective we want the poor to consume more. This was also being done to support the business model, in order to generate money.
(4) We added a TV to the solar system package. This improved the payment of electricity bills. Normally if people didn't pay, the electricity was cut and they would take time to come pay the bills, because they could just light some candles. Now, because the TV is also cut once they don't pay, payment has improved.
(5) Type of business models to be implemented. We had to drop the co-op model. We are researching a classic transaction model. The user has no decision-making power

Aim:
To develop technology to a point where a fee can be charged for the use. This is then used to pay for salaries and maintenance.
Government level: To change/ use policies.

Degree of new tech knowledge:
Incremental, Radical, Architectural

Type of Innovation
Product/service and process

Project champion

[redacted]

Institutional Embeddedness
Platform-based

Project B6

Interview date: Monday 20 June 2016

When did the project start?

2014

What was your role in the project?
My role in the project was similar to the role that our centre takes, which is a facilitator between the academics and the students on the one end and the use of technologies on the other hand. We try to marry the most effective use of the one to serve the other one. In this case Computer Science was the first thing and our Centre for Special Needs Students - they made a link. They approached us with a need, specifically the students who cannot be in a typical classroom. Examples are Asperger's, social anxiety and people with physical disabilities. The driver was this aspect of students who cannot be in class and how we can help them. The university also has a project to develop a kind of streaming and archiving solution for the whole university. And so we saw this project as a way of testing both these things. On the one hand it is a system using some of Google's building blocks and tools, but with a specific focus on how it impacts the lives of special needs students. I was more involved with the one project and then I became more involved in the group. The management of the project was very democratic, we kept everyone in the loop. But in the end I was the project administrator. I made sure that the Ethics clearance was done, I put together the presentations, it was my responsibility to make sure everything was done, I provided support to the lecturers.

Contributed?
Other departments: Computer Science Department, Centre for Special Needs, our centre, Teaching and Learning Enhancement Division.

Business: For this project we used Google Hangouts On Air, which means that you set it up as a channel and it enables you to stream live, but at the same time it also records onto a YouTube channel. We saw the possibility of using Google Hangouts as a teaching platform.

For this project we used Google Hangouts just as it is, but for the bigger ongoing university project there is customization as well for the user, to make it a bit easier for the lecturer and the student to actually create e.g sessions and learning events. In this project we did a lot of things for the lecturer, but in the system we are developing the student and the lecturer will be able to do it for themselves.

The system is being developed by our IT Department and a company called Grove and they are Google partners. So Google Africa sponsored the development of most of the system which is almost finished.

We always use the data and feedback from this project to conceptualise the system. I think th concept of universal design was very prominent from the start. This is what the special needs colleague also brought in.

Budget?
Project around special needs: R15 000 (for the research project)

Funding?
Stellenbosch University.
Scaled project: SU and Google

Critical Inputs?
It really starts with the Academics (the lecturers), it starts with a strong willingness. It starts with their openess to change their teaching a bit.

To have support with the system. Somebody who can come to the class to make sure it is working. They soon found out that you probably need another person in the room as well, who can actively monitor the online space for questions an represent the students that are not in class, so that the lecturer is made aware of the students that are not actually in class.

The system must be robust. We chose Google Hangouts on Air, because it is a strong system. It is not going to break down, it is proven. There are no storage issues. By watching it on YouTube it can be viewed on any screen in any bandwidth situation. In class we had to make sure that the lecturer could connect to the internet.

The students' willingness. We asked for students to volunteer. 20 volunteers from Computer Science and a second round with 18 second-year students from Economic Studies.

Tested?
Yes, two pilots: 20 volunteers from Computer Science and a second round with 18 second year students from Economic Studies.

How many people are using?
From our data we know of the 38 involved in the testing phase, but many have continued using it. We are not tracking the amount of people using it.

Critical decision factors?
Lecturers: Having video archives of the lectures have proved very handy.
Students: That they find it useful.

What are you aiming for?
Broadly speaking, the whole idea of taking the design of this thing forward is the whole idea that you can use this system from any classroom of SU, even from any office space or internet enabled computer. So that if there are students who want to take part but don't have flexibility or cannot take part in any other way - that we could serve them. We are designing a product that is so affordable and so easy, using the building blocks that we have, so that it could work on any computer that has a browser and is internet enabled. Then it will be successful. Must be robust and scalable.

Seeing what is available in classrooms and what can marry with that.

Project Scaling
This project served as a pilot for the bigger university project. We have now become part of a bigger project with IT and University and Grove, Google. And now it is being marketed to all SA universities. So there is a spin-off. We have done presentations with all that IT directors of all the Universities in SA, and this tool that we are developing has been showcased and the data that is used to say that students like it and lecturers find it good comes from this project. So the project had a broader impact as it were.

We are developing the new system as an open source system. There are costs involved in customising and integrating it into a specific institution. The whole idea is that other universities won't have to redevelop the whole thing. We are payong for the development and sourced funding from Google to also help with the development.

Quantitative/qualitative?
Focus groups of lecturers and students. We also tracked views while this test phase.

Outcomes for the university?
We are interested at looking at special needs students. Through this project we have become much more synthesised and aware. It changed my practice as well. And to meet lecturers for whom this is very important. That is why universal design is now very important. Because from now on whenever we design something we will never forget to think about whether we are including all our students.

It did give the university a chance to present what we are doing at national and international presentations. It was worthwhile for the lecturers as well; they became 'champions' of technology.

Institutional embeddedness:
Stand-alone (project) but the tool we are developing is platform-based

Degree of New Technical Knowledge:
Incremental: Using technology in a little bit of a different way, it was social, but know academic.

Dominant University Mission
Student education

Project C1

Interview date: Tuesday 02 May 2016

When did this inclusive innovation project/process start (year, month)?
It kickstarted in the beginning 2014

What was your role in the project?
This is an important question. I am often the face of this project from UCT point of view. But it really stems from bringing fishery managers, fishers and me as a facilitator together. So I am project leader in a way but the community leader that works with me is also the project director, the fishery manager that leads that whole program is also the program director. But I am the main one that brings it all together.

What are the main objectives of the project?
Transform the fishery sector
Transform the way we produce knowledge
Transform who fishes and how obviously people benefit from the fisheries.

You refer to the "way we produce knowlede", could you please elaborate on that.
Yes, that is the core componenet, the platform can do a whole lot of things. But the pilliar of this platform is around the producing of knowledge. So I am going to keep it simple: the fishers authority has a particular way of developing science, of generating science of translating science into management regulations, into policy, inot permit condutions etc. It is very top-down, like in so many other countries. It is probably the best they can do. They try and gather as much data as possible, its very extractive. That is their approach - if you go out to any fisher community worldwide and in SA, most fishers will tell you a different story to what science tells you. Some because they don't trust the scientists/ because they hate the scientists/ because the scientists never chat to them. But very often because they hav a higher resolution image of the fishing and of what is going on there. They are there every day, they perceive all these things they experience these things from atmospheric, oceanic, various biological species related things - they just have that 'feel'.

But there are very few projects out there or intiatives whether they are government/NGO/university driven where ther is a genuini opportunity to bring that at the same table. I have been in so many workshops where fishers and scientists just do not get along. They always end up fighting. And the main reason is that they don't talk about the same things. They don't talk the same languade/dialect but also the way they perceive nature/stocks is juct very different. I am generalising - there are good examples and moments where that really works. But overall that is how it is set-up.

So in our effort to drive sustainability, in our effort to drive stuartship, to drive sustainable management of resources, to drive socio-economic development efficiently in communities - it is so simple but the starting point is really about finding ways to bring knowledge on fisheries, various kinds of knowledge/ different ways of knowing - to bring that to the decision making table, to the co-management table. So this is what I mean when I talk about co-producing knowledge. Where fishers have ways of tools/opportunities/moments/processes to bring their knowledge to the table and government and government scientists have ways to do the same but to also hear what the other party has to say. From a policy environment there: there are a lot of policies that drive co-operative governance, that is the best practice. Bu in practice that doesn't work out. So by co-producing fishery knowledge or being able to not just co-produce but co-present this information in this digestible package that people can engage with we can assist. We can assess trends we can look at various images of the fishery from different parties and develop new knowledge that can try and adress dome of the challenges we have. So in this particular project - fishers produce knowledge, some through the app some in other ways. And then various other stakeholders like NGO's, fishery scientists within this unversity or within fishers authority, managers within fishers authority - they also have their own knowledge. They often have a macro view of things and they then present that aswell.

Its tricky, people don't always get along and in SA there is often racial tensions - there is a history of that as well. And we felt quite strongly (an app isn't going to do everything) but having an app that is almost a neutral meeting point or something everybody can engage with where everyone can meet or a system that is able to present and put it on the table and then having discussions around that. We felt that was a good process to try out.

And when you say we?
Me, fish workers I have been working with, and various people in fishrsies authorities including some of the scientists. So a small core group of people from completely different disciplines coming together.

How would you describe the nature of the project ?

Between Developmental/non-profit and Hybrid/social enterprise

The app itsels is completely open source platform free for anybody to use but there had to be some sort of sustainability

model around that. Governemnet could subsidise it but the fishers still need availability of smartphones. They need tobuy airtime. There has to be some type of operational budget, not for profit. So thats the value chains comes in. So we are working with retailers on developing platforms where fishers can engage with various retailers. As a retailer you coul pay say R100 for an app but it offers you a whole bunch of services. That can then cross subsidise the maintenance, the hosting, the full development of the platform. So there is some type of businsess model linked to it. Different versions of the app. The retailers could pay for the service to be able to communicate with the fishers on the dock
But for a fisher, for a co-operative, for a fishery manager it is completely for free.

Who, besides you/your department, has contributed to the project?

Other departments UCT:
Biological Sciences, Computer Science (ICT for D centre), e-research centre, African climate and development initiative, The knowledge co-op, Humanities faculty (department of Social Sciences) - quite a
Other Universities SA: Rhodes Department of Fisherie
International: University of Washington (built Open Data Kit (ODK2)), West Indies
Local Community: Fishers
Government: Fishers Authorities: Agriculture and Trade and Industry

Businesses:

- Salesforce (provided free licenses to use their products and tech support)
- Sonus Cloud: Cloud communication and data ownership
- WWF: Funding from Pick n Pay and Woolworths
- Seafood restaurants are keen to get involved

NGO: Masifundise Development Trust they have set up a large network of fishers called Coastal Links has regional workshops

What have the university contributions been to this innovation (yours and any other university representatives)?
Me and my whole infrastructure, students, student bursaries, staff collaboration
E-reasearch centre - played a big role, helped with business model, helped with apllications for funcding.
Getting media attention

Funding?
Vodacom foundation gave seed funding in 2014, NRF, DAF Fishers Authority, TIA

Budget
Between R1 million and R10 million (the process is expensive not necessarily the tech)

Has the innovation been tested? If so, where and how?
Catch recording and reporting that data has been tested (Module 1).
Results: a lot of fishers are using the app, whether they go fishing or no There is continuous feedback about what to do and what not, new version has been released, made mistakes and learned from them, disrupt the established marke (exampof fishers setting prices at dock – they were able to set a higher proce becasue they all communicate on app and set a higher price)

How many people are using the innovation
+/- 100. Fishers, 15 monitors from government and 1 co-operation.

Effects of innovation measured?
Quantitative Metrics: Daily wage recording, daily usage of the app, fishers uplouad images and make comments, the profit is recorded, quality of information that is recorded.
Gps: where it is used, how it is used, types of phones used

Qualitative: workshops are qual, power and politics, tranparency of project, how to manage only number of fishers that could use the app in pilot.
Daily interactions: Interactions between fishers and mentors,

How do you get information on use:
We can see use and engagement of application. We have a series of interactions from daily interactions through people in the fishing communities through daily chats with monitors. And then regular meetings with various groups.

Outputs, outcomes?
Big drive from fishing community to be part of the project
Fishers authority wants to use this

Critical decisions?
Partnership between fishing community, UCT and government
Bottom-up project but governemnt support has been crucial
Slow iterative process: slow time management

Critical to people's decision to use?
The app has to 'work for them' and the fishers have to have a sense of ownership

Outcomes:
Research Publications, R&D partnerships, Presentations, Student education/training, Money/income

Student involvement:
Students need to be well informed before they go into the field and then they first have to go into the field before formulating their questions. Student involvement is not always possible.

Control Variables
Combination between product and process innovation and it is an incrememntal innovation but in the fishing context it is a radical innovation

What would you like to know about other projects?
How are they doing it? How do they engage? Someone with matching criteria.

Project C2

*** The interview of project C2 was conducted by Dr Marjolijn Dirkstehuise and the transcript was used in this study.**

Interview date: Friday 28 April 2016

When did this inclusive innovation project start (year and, if known, month)?
The starting point was gradual, because when I came from Europe [to South Africa] in 1992, **I was** only exposed till then to first world pathology. And then it took me a while to realise how different the pathology is here; that we have these young patients, in contrast to the old 'ducks' in Europe. And then I realised that the heart valves available, that were developed in the US and Europe, are all made for these old people. And if I put them in these young people, they degenerate fast or clot up fast, and need re-operations, which very often in Africa are not accessible. I had teamed up with the biggest medical device company in the US, Medtronic, when I was still in Zurich, and they were fine with the idea of taking my collaboration down to South Africa. They gave me a very long leash and said: whatever you do is fine with us, we just want patent rights. In those days, that meant nothing to an academic. As long as we got our funding. So we had an almost 20-year relationship with them. And in that relationship, I already started focusing on improving the heart valve. To make the existing surgical heart valves better. We had eventually I think 29-30 patents with them on treatments, which would have dramatically increased the longevity of heart valves in young patients. But in the end, the third world market did not justify from a business standpoint for an American company to go through all the hassles of FDA approval of radically different products, because for their old patients, the valves that are currently available are fine. And the realisation process started slowly on our side that no first world company will ever pull it through if we don't do it ourselves. That was the first step. And then, when we started into the next level, the first thing was to say: Whoever has access to cardiac surgery gets bad products, because first world products are just not good enough for the third world. But then I realised more and more that the majority of the developing world AND emerging economies had simply no access to cardiac surgery. That was really a wake up call, because even in China in 2015 the entire Western half of a country with 1.3 billion people doesn't have a single heart centre. So this is not [just] an African problem, but they all have twice as many people needing life saving heart surgery than people with HIV in the whole world. So this is a huge problem; 66 million versus 33 million HIV patients. Then the next step was relatively obvious, to say the cutting edge technology in the first world is build on catheters, on wires, but it requires extremely expensive equipment and is a very sophisticated procedure. We said we now have 20 years of knowing what to do to make valves last longer, can we find a way to make valves last longer, but get them in with simple means without open heart surgery.
[So, both product and process innovation]

What has been your role in the project?

Founder of Straight Access Technologies

Inventor/originator

Designer/developer

Implementer

Champion

What is/are the main objective/s of the project?
To find a way to make heart valves last longer, and get them in with simple means without open heart surgery.

How would you describe the nature of the project?

Hybrid model – profit and non-profit
SAT is for profit. The model taken is a for profit model with the understanding from the beginning that it will have a profitable arm, which cross-fertilises the non-profitable arm. So the simplification of the process, which is very 'en vogue' in Europe right now, namely cathether based heart valve replacements – simplification is attractive for Europe too. And the best example is very often, products get tested in the developing world. It is the opposite [here], we developed something here and we have lined up 6 centres in Switzerland, Germany and Austria to do the first-in-man with a product developed in South Africa. They approached us, because they realised that these simplifications are really attractive for them. So those aspects that are attractive for the first world have potentially a very big market there and a very profitable market. The nonocclusive tallentation [?] balloons, that you don't need to stop the heart because the balloon allows, while it is opened up, for blood to flow through - very interesting for the first world. With that profit, we would then be able to cross-fertilise valves and deployment devices for emerging economies and developing countries at cheap cost. That has been the whole model from the beginning.
Who has been involved in the project and in which stage/s?

[Role of the university (UCT):] We started everything outside the university, the ideas, the patents – everything. But the fact that I had built up an infrastructure here [at UCT] during my 20 years with the American corporation [Medtronic], which is unique – so we have everything here, which I would have wished for, for a company – so therefore I approached the university and said: don't you want to become a shareholder and in return I am allowed to utilise my own facilities here. And now we are in the third round of funding, and

the university is seriously contemplating putting money in, for the first time. **Key reason for UCT to be involved** Doing well while doing good. The university was on board when we started, in 2007-2008.

Who have been the other key stakeholders in the process?
The founders, a group of 3: one is an internationally reknowned scientist in the field [redacted] from Wake Forest University [North Carolina, USA], and one is a professor of polymer chemistry in my own department [redacted] And then we invited the university, so were four [shareholders]. We financed the first steps out of our own pocket. Then the university also came on board with a bit of money. And then we started going to the typical state incubator funding agencies. In those days, it was the Innovation Fund, which after a year of doing due diligence imploded, so we lost a year. It was replaced by TIA – the Technology Innovation Agency, based at the Department of Science & Technology. Eventually they came on board for the first product with R18 million, but we had to find 30% from private funders, and that was when Bidvest came on board, in 2012. They said: TIA is funding one product to which we contribute R6 million, but we are also adding R18 million for your other products, for the valves. Because the first investment would have only allowed us to develop the deployment devices, not the heart valves. Bidvest said from the beginning: we will give you another R18 million so that you can get started with the heart valves. And in return: shares.

Project budget
More than R10 million

IP/patents
They all rest in the company. In order to comply with the SA law, which has this very annoying institution called NIPMO [National Intellectual Property Management Office]. They have I think a terrible law, which prevents a lot of overseas investment. Because it says if any public funding, as little as R1, is part of R&D, they can walk in on the IP at any time – have it, claim ownership. So therefore we have, from the beginning, with a little bit of post/retrograde clean up, made sure that everything – where any public institution is involved – is at cost. So for instance, with the university, if I have a student at SAT that I need to supervise, SAT needs to pay the university for my supervision time at full cost. That prevents NIPMO from having access rights, but it is actually something only an idiot could have come up with if you want the country to develop to more refined industry, but that is what the situation is.

Heart valves: Where in the process are you now?
We are 95% confident that we will have the two-in-man in a year's time with the deployment balloons in Europe and the first set of valves in Africa or developing countries, or emerging markets – in perhaps China, but definitely here in South Africa.
We have practically proven concept in all products in animals already. We are going into long-term implants in September. And have bench [?] testings far beyond the requirements of the FDA for instance. You need 200 million cycles; we are in the 300-400 million cycles. You need to have accelerated wear testing for heart valves, purely on the mechanical side – where you say I can test 12 years of life in half a year in a machine, and this is approx 400 million cycles. Our valves are beyond the FDA requirements. There is also the biological side [to testing].

Performance metrics/success indicators
So you need hundreds of millions of cycles without the valve falling apart. And then of course, in the animals, to see that it is blood compatible and that it doesn't clot up, that it continues to work in the body.
We have started talking to NGOs. One of the investors now, with whom we are in the last throws of negotiations, is a big NGO with a network in Africa. They plan to invest in the business with the view of also being the supportive downstream organisation that gets us into Africa. But, as I said before, it is not only the developing world, it is also emerging economies – I am in China in two weeks again to talk about how to roll it out there and with the Russians we are much further. I have been in Russia so many times now. They approached us and it is really a group driven not only by the government, but also by opinion leaders in the field – cardiologists, cardic surgeons – who say that this is tailormade for Russia. So we are starting to finalise a joint venture agreement now, in July, where they would also do part of the production there. It is a Public-Private Partnership [the Russian JV partner]. The government gives them a lot of incentives now to break through the sanctions, because all these high tech things like heart valves and so forth fall under these sanctions. Even if they could afford it, but also with the Roebel falling into empty bottom, apart from not being able to afford these extremely expensive first world products – one valve is 30,000 euros- they wouldn't get there. So for them, it is double interesting. There will be a license agreement for what is produced there, and a distribution agreement for what is produced here. And this teleconference now was with an Austrian-German consortium, who want to start a JV based on one of our patents where they want to use it for another first world product, which we don't have in our range, but what they could see as a potential downstream product from one of ours. So we would put out patent into that JV, and they would put the capital in.

What have been the internal/university outcomes so far?
We have only one high impact journal paper out yet, because the first 2-3 years was about getting something out that works. We have 3-4 now in the pipeline, so publications will start rolling soon. We have 4 students at SAT doing degrees and almost most importantly, in a time in which it is very difficult to retain clinicians in an otherwise not so attractive state environment, we have my own team members on the surgical side – cardiologists - and to a very high degree anaestetists enthusiastically on board and they really see that being part of this academic medical set up, they are also part of some sort of cutting edge developments where even the first world knocks on the door. And this is a very strong incentive, which one mustn't underestimate. Because everyone always thinks it is just the high income which they get in private, but many of them are just disappointed in the mediocrity of university medicine, so if one can offer them this sort of thriving environment, it makes a big difference.

In your opinion, which have been the key choices in the process that have had an impact on the outcomes so far?

First one, clearly to bring the marriage with the first world corporation to an end, even if it was a very happy marriage, but with no outcome.
Secondly, to secure the initial IP with our own money to be able to stand on something.
Thirdly, to invite the university to become a shareholder and in exchange utilise my own lab facilities. And fourthly, to revive my own European networks by talking to them, getting enthusiastic first world opinion leaders to not only buy in but to be fully on board of the project. Because a medical project only finds its way to the market if opinion leaders can be convinced and start telling the story.

Degree of new technical knowledge in terms of the affordable heart valve?
It is not actually new technical knowledge. It is having no shackles, for instance the idea for plastic heart valves has floated around for 30 years, but with all the regulatory stringency in America and Europe, nobody dared it. And at the same time, there were some unique ideas, like with our hollow balloons, but out of the necessity of not having the infrastructure, which makes it so easy in Europe to just stop the heart. And we say, if you don't have that, you need something that allows the heart to continue working while you do it. So again, the pressure of circumstances perhaps…

How would you describe what is new about this innovation?
First of all, to combine modules, which as a module are already stuck in fear in Europe – starting with synthetic materials. Since the […] scandal in 1984, nobody touched new synthetic materials, because they were sued for 4 billion in 1984. So internationally, we are stuck at the level of '84. So we got the fathers of all those materials, in their old age, we got them here to develop it with us here, because they said we can't do it in America, we can't do it in Europe. But when you get it to the point that it works, the hurdles in Europe and America will be overcome.

Project C3

Interview date: Tuesday 14 June 2016

When did the project start?
Late 2011

How would you describe your role?
I am a director of the organisation so I am involved in all the managing aspects of the organisation. Our organisation is very small so we have a very flat structure - we are involved in everything, we're involved in rolling things out into communities. I am an engineer originally, so my responsibility in the organisation is everything that relates to our fire detection system. I head that up and then all the supply chain management. Also continuously our work is about developing a business model that will scale and work through which we can reach the most amount of people possible. Technically speaking I am also in charge of modelling social impact in our organisation.

What do you refer to when you say social impact side?
One of the things that we are continuously doing is we have someone in our organisation (Clive) who is a community liaison. He goes into our communities on a daily bases to do roll-outs and distribution of our system. He also goes back on a daily bases to get feedback, to explore new business models. Every time a fire occurs we will do a follow up with that community, or every time we get any kind of event we will go and engage that community, find out what has happened and get feedback. These are communities where Lumkani is already in place. The only communities that we go to are either ones that we are intending to explore, because we understand that expectations are a very complicated thing, so we don't go to communities unless we either have a way to roll out in that area or an intention to over time.

We are currently in over 7000 homes across SA. Clive is constantly going into these areas and either exploring new options/ new business ideas that we have with them; or going back and finding out about specific fires that have happened, experience of the system etc. This is how we set out to understand our social impact. I can say that there are 12 large fires that our system has detected over the last year but, we know that the system has played a large role in mitigating the loss of life and property.

Most important metrics or measures of success?
On a very practical bases, as much as we have many different dreams of what we can do in communities, the main thing that we exist as an organisation to do is to make those communities safer for people to live in. Therefore the metric that we 100% stand by as an organisation is keeping track of fires, has there been any loss of life while the system has been present, the number of homes that were damaged, as well as qualitative feedback from those people. Because the system is in the community is important to know if the community has a positive experience with the system. Sometimes you might see the reverse - in some areas where there have been lots of false alarms you might see the opposite of this.

We have developed a checklist, so when our community liaison goes to communities he has a wide range of things he is checking. One of the most basic things is whether batteries are still inside of the devices. That is a very interesting thing to see the difference between what people conceive as buy-in from the community and then there are some very practical realities that you come into contact with. For us, one of the simplest ones are: "do people see value" is a very theoretical question, but whether someone is willing to change their battery their device when it dies, is a very practical way of noticing how people are engaging or are aware of the work that we do and what the system is intended to do. If the battery is not replaced, the device is not being used. Traditional aid works as follows: a

new technology is just dropped in and then it is only used briefly/ not at all and then it just sits there. And that for us is the worst ideas. And that is a challenge for our organisation - for us there has to be sustainability. If it only works for 2 years and ends once the batteries die, then there was no point in doing it.

What is your experience so far around continued use?
Battery changes are something that even if you look in wealthy areas, people don't change the batteries in their smoke detectors. In these informal communities we are seeing a serious struggle with that - we do get lots of stories of people who are changing it and we do a lot to remind them. We send out sms's to whole communities to remind them, we filmed a soap opera DVD which explains our system and will be released with each of our devices. It explains the value of the system. We have handed them out to our older communities and have been getting a lot of positive feedback. People say that after watching the DVD they changed their batteries.

The reason we put so much energy into this is (A) there is a lack of understanding of how the system operates, and (B) the batteries are not being replaced.

Is the measurement around this, is it slightly more loose i.t.o going into communities or do you actually have some way of tracking things i.e. is it quantitatively described.
We have centralised smart devices in our communities, and that gives us a degree of quantitative data i.t.o the fact that we have these centralised devices and they will ping each other and that will tell us that there is a network in a community. This will tell us that there are a certain number of working devices in a community. It doesn't tell us whether every single device out there is working, which is actually required. But not every device is able to communicate on its own battery level. What we do is every time that the community liaison goes into a community, he will go into 15 homes and check their devices and we get that feedback. He does between 5-10 communities in a week.

Briefly describe the process of the business model development?
The first thing we started off with was a minimum viable situation. So we were just trying to get devices out there. So to start (end of 2014) we approached NGO's and corporates and other organisations and they were co-financing the system. We rolled out our first system with an organisation called CORK, they basically paid 80% of the device and the community 20%. At the time the device cost R90. 3000 of our devices that are out in communities were done through CORK. That was the model that we applied throughout communities around Cape Town. Communities could apply to be part of this thing called the city fund, and then they would get 80% of the system covered and they had to come up with 20%. They could pay the 20% in advance, at the time of delivery etc. were minor business model changes that we were playing with. We then also approached corporates and some for example bought for all of their employees, Shivers Reegel paid for a whole bunch to be rolled out into 3 communities across SA, Red Cross, World Vision and other large international NGO's were purchasing the device. And that is how we got into 7000 homes.

It has been either through co-financing, couple of examples like Shivers Reegel and World Vision that were 100% funded by the NGO. at the time we were very uncomfortable about the idea that devices were going out there entirely for free, because we knew that like most aid models, when things go out there for free, people don't engage and don't consider the buy in effect. We have been testing that and trying to see the effects of the for example how much people know and the difference between those who did and did not pay for their devices. To be honest there has not been a drastic difference. Whether someone does/ does not change a battery is not dependent on whether they paid for the device or not. Our main thing is therefore how we can create buy-in whether or not somebody has paid. We understand that we have to be flexible and there is definitely a great ease in distribution if people are not paying for it.

Our business model is going forward. Because of these questions of battery and because of the fact that you have to be able to maintain a system. Every single formal sector that has a fire detection system, those buildings are maintained with that. And in an informal reality, it is much simpler, but our central monitoring unit has cost: we send sms's every time there is a fire so there are recurring costs. So we have to find ways to make it sustainable.

So there are multiple different models we are trying at the moment. Mid-way through July we will be piloting a joint venture between [redacted] The City of Johannesburg [redacted] will have a low cost insurance product available for shack fires specifically, where people can in exchange for a monthly insurance fee, they can get cover on their homes in the event of a fire to the value of a specific amount. That is a pilot that we are running with them at the moment. If that works it is a huge business opportunity. The big gap there is that people actually really want to pay for that. Originally we wanted to sell the devices to the community because (A) it shows people want the product and (B) it is very sustainable. But the reality is that it is a grudge purchase to buy a fire detector. As much as people will say that it is their greatest fear in life, but none the less, buying a fire detector is not something that you want to do it is something that you have to do. That model of selling directly to customers has always been complicated for us, because there is the conflict that people will not pay the full amount (we are quite certain of this), will they then pay a certain percentage? Yes. How do you then fund the remaining amount continuously? So something like the shack fire insurance space we found through months of sessions with the community, is something that people are extremely interested in. It was an idea that we were playing with. And then the City of Johannesburg approached us with the possibility to form a joint venture. We will run a pilot with about 4,5 thousand homes. With this partnership model the City of Johannesburg will be providing safety equipment, there will be 9 trained full time people who are working in those communities and distributing the insurance product as well as being fire safety people who have access to that equipment. So we are reducing risk for [redacted] we are increasing community security so people are in some ways incentivised to say: "I am actually also paying for my community to be made safer and at the same time I have a buffer if anything ever does happen to my home, I will actually be able to clame." This model would be sufficient to generate an income for us. We are at a stage right nowhere we have got 7000 devices in homes. We are no longer at a stage where we are desperately trying to get more out there in an unsustainable way, because we are experiencing the reality that 2 years down the line it is going to begin to stop working if there is not some level

of continued effort. And we are putting the\at continued effort into the 7000 homes because it is important to us but it is not sustainable as an organisation to continuously spend that money. There is no revenue for the actual sale of the devices. And that is always going to be a challenge for an organisation like us. In the partnership model it is slightly more complicated, we are going to be managing the distribution of both the fire detection system and the insurance product. So [redacted] is offering us an insurance rate. For us the fee includes all the people that we will be hiring for this. The City of Johannesburg is purely a partner in terms of skills training, equipment etc.

Is there any component of post-distribution revenue in this model?
In this model there is a component of post-distribution revenue, because we are managing the system. So as long as people are paying their insurance, we are insuring that everything with relation to fire safety in that community is up to standard. The identity of the organisation is changing.

Other models you are exploring?
Other major models that we intend to explore are social impact models. The first one in SA was recently done, with Western Cape government and they are very interested in the models and it is very refreshing for government because we are not asking them to procure something, we are saying that we will just do it and then they can pay us based on an outcome. So they do not have to take any of the risk on. In the social impact model, the metrics could change, but in the simplest way, based on how much money we save government i.to fires that appear in informal settlements in certain areas we get paid out a certain percentage of that. This is measured based on the base-line that the government already have. We are currently engaging with City of Cape Town, and they are giving us data on how many fires they have had in certain areas, the costs associated with each etc. In this model out whole job as an organisation would just be: prevent fires no matter what. Put as much energy as you can into making this happen. Which is why we exist. But sometimes a lot of your work is about impressing a corporate or making sure that there are symbols here and there and looking for sponsors. Whereas in this model, the whole purpose is to do everything possible to ensure that this system is as effective as possible. We would love for this to be reality, but the truth is that government is an extremely hard partner. We have got confirmation from the City of Cape Town that they are very interested in this project. They are giving us all the cost in relation to it, and after that point in time it will be up to us to start. It will have to be like a tender for outcomes as opposed to a tender for procurement. So we are still fairly in the early stages i.t.o we do not actually have an agreement with them, but essentially we have the state of interest and they are giving us all the information that we require. Financially we would make the upfront investment and that is the risk that we will take. Then annually there would be an evaluation of the situation in a particular area. From a sustainability point of view, and agreement of government won't be for a period longer than 3 years. Government would then have to review whether this is a desirable thing. I think one of the potential outcomes at the end of all this might be that we roll this out in a particular area and based on our experience of our system let's just say that there was success in this regard, and for example the amount of homes destroyed in a certain area is reduced we get paid a certain amount from City for having successfully dozen this. And perhaps over time they would either see that there is value in procuring this, and this is almost like a proven concept, or that we are seeing this and this is working and we want to continue this sort of arrangement. In a business sense, the only reason we are continuously putting resources and energy into that area is because we have that agreement with government so they would have to evaluate is this working, is this valuable., if so do we continue or do we just procure the system and say we will pay you on a regular basis to maintain the system.

In this social impact model, is there a role for [redacted] beyond distribution?
Yes, every time there was a fire we follow up. To make sure what has happened, and gather as much information. Our role would be to prevent fires as efficiently as possible. Then we would (a) be very stringent with checking batteries (b) be there to ensure that the system is properly maintained, that every element, smart device is working full time. Potentially we would also be supplying fire extinguishing equipment, because that would improve people's ability to deal with fires, we might be organising training to do with fires. We would then be doing as much as we can because at the end of the day we would get paid if fires don't occur.

What type of organisation is [redacted]?
We are a social enterprise. We exist to make the world a safer place to live in in whatever way we can. We want to be a sustainable profitable organisation that can do all these things, but profit is not what our shareholders care about. The reality is that you have to play that game because if you can't sustain it, we surely can't sustain the impact of what we are doing.

How does the system go about 'stopping' fires?
The reality is that the fire brigade is very ineffective with dealing with township fires, because it is extremely dense environment and it takes extremely long to get there and some areas can't be reached by a fire truck. So we are alerting whole communities to the fire and communities respond. Why? - Because is a fire happens it is not your problem in your home, it is the whole community's problem, because fires spread so quickly. So from what we've seen over the past couple of years, communities do respond, they have advanced methods of response, but once a fire reaches a critical stage - the community can no longer deal with it. Then the fire department must come and deal with it. So our whole thing is about giving the community as early warning as possible to give them as much time to actually be effectual in their response. Then our system can notify the fire department, and we have been in conversation with them for a long time to integrate that, but they are beurocratic and so take on a new system like that means changing how the fire departments works.

University contribution?
Primarily Samuel represent the university. Anything that Samuel does for us, he does as an employee of the university. It is almost as if the university is doing it for us. We have patented the technology which the university was very involved in, so they assisted us in the patenting process. They ran the entire patenting process, currently it is in UCT's name. It was very advantageous to have somebody who understands that legal background. And in the early stages while we were making agreements with other organisations, UCT was

very useful because it allowed us to have some sort of cloud behind us. For example when we were making distribution agreements with other countries, UCT was very involved in that. (The UCT IP department) because of the fact that it has got to do with the IP including licensing etc, they were very useful for and they had legal background there. It was through them that we got the financial opportunity to apply for the Technology Innovation Agencies fund. It was our first massive funding, I think it was R450 000 that we got awarded, and again it was the background and cloud that UCT provided that made this possible. Any contribution that [redacted] has made technologically is also from the 'university'. We are currently working on a new manufacturing jig is for a new product, but it is the same technology. It has just been improved, its been through testing processes, its gone through certification and other very practical things like coatings and technical and customer experience in terms of where the button must be etc. This is like 2.0. It will completely replace version1.0. Technologically it's just about fixing bugs in the system. And a new casing to make the changing of batteries easier.

UCT is the holder of the IP?
Essentially we are going to have a licensing agreement with them. Then every time we sell the device we pay them a certain amount of money. At the moment I think we are about to have 50% of the IP assigned to us because we did technically do at least 50% of the work.

Type of innovation?
It is a product and process innovation. You can't separate the understanding of how a community operates from how the device operates. We first developed a box that rang in your home, we had no understanding of community. It was paternalistic and disengaged, we designed something in the university and thought this could work in such an environment. Once we engaged the environment we learnt a lot about how little we understood about this environment, how little we know about how to deal with this challenge. The only way was to sit with communities and engage with people who live that reality on a daily basis, and hence we could learn as much as we could, without living there, what the reality was. What we do is we alert whole communities in the event of fire and that changes their process of response. Because suddenly they know, as a community, that they have a communal alert system in place. And hence it can change how they respond. They can be more efficient, more planned, more structured in how they do things because they know that the whole community is being alerted currently. They are receiving SMS's and an alarm is going off to say that there is a fire. The only reason we did this was because we were sitting in communities and they were saying that this thing might be ringing in my home but my next-door neighbour doesn't know, and I am asleep/ not there then what? So the conversations began asking, what if we alert more people? Because people said a fire in my house is not my issue it is my communities issue so we have to let everybody know. So we developed new technology in terms of developing a whole wireless network that is operational. So there is product innovation, but it is all based on a understanding of community process that would enable that product to be valuable.

Project C4

Interview date: Tuesday 10 May 2016

How would you describe the Innovation?
The components that are made here in the school and in the community. The platforms as an intervention is relatively new. Usually in terms of service delivery the community would get pre-cast concrete toilets with a tap mounted on the side, but nothing was done to the surrounding area, actual surface or washing facilities. As a facility in the community it is a new intervention. We also do a lot of prototyping for the components which are either made here of we train community members to make them. We usually try to use traditional technologies in a different way, but we have also experimented with more modern technologies for production, for example CNC cut timber - numerically controlled cutting.

When did the project start?
2011 started by a Chilean architect and a UCT staff member [redacted], they started it and I took over in 2012.

Why did the project start?
Chilean architect took a walk in the rural community and noticed the water points and how there was nothing around them where people could sit/stand/wash. He then approached the department and they managed to get some funding for the first platform.

How would you describe your role?
Project leader. I have to source all the funding, and go to identify the sites. Help to brief the students for the design course. I convene the technology course in the second year. I then, with one of the studio lecturers, combine the designs and finish the final drawings. I then meet with the engineer and suppliers to get the drawing ready for implementation and I run the project on site.

Funding
Charitable fund funded the fisrt 4-5 years. Then they pulled out in 2014 [Budget of R60 000 each]
2015 was funded by the UCT department, therefore our budget was much more limited. [R10 000]
2016 budget is still unsure

We don't have long standing funding. We have to apply for funding every year, so we never know how much we are going to have. This effects the scope of the project. We get material donations from private sector. But to get cash is a challenges

Budget of the project?
Including materials R85 000 for the bigger ones
Smaller ones R25 000

Objectives of the project?

Teaching for the students, providing a learning opportunity and letting them experience working in a n informal settlement. The teaching component is important for the students and staff. (Innovative teaching)

We also try and do knowledge transfer where community members can also learn something, and then it also happens that community members teach the students a few things.

To provide temporary employment for unemployed community members. Some of the training in terms of making components gets transferred and we try and employ local community members to make components and work on the platforms. (Skill learning and job creation) [For each platform we have employed 1-4 local community members]

Use recycled materials

Ways of integrating it into different curriculums: Architecture department it starts off in a design and theory course, 2nd year design students go to Imizamo Yethu community - community members take them on a tour through the community showing them some houses and the previous platforms. Then they spend 2 weeks designing a platform for that year. There is a community liaison who points out a few possible sites for us, we then choose one that is practical and accessible. Then the project comes into the second year technology course. Where they spend 2 weeks designing and building different prototypes. Then in June during some students can volunteer for the Imizamo Yethu build.

Community input on design?
In 2 of the platforms we have given the designs to the community liaison and he went around and asked for community input around the platforms, but I think that is one of the things we have not managed to get right. Is to have public participation. This is mainly due to time constraints. Because it is in different programs it is difficult to get everything in place, do public participation, and go back. If we had more time in the design course then ideally we would like to do more public participation. But usually we just run it by our community liaison and he gives feedback.

Community Liaison: Social worker who lives in the community. Has been involved from the start of the project.

What are the outcomes of the project?
So far 4 platforms on informal portion, these were washing platforms. And 2 were pavilions with a water point installed in the local soccer field. In most cases we were able to add 3 taps and a platform. At the soccer pavilions only 1 tap.

Summary of outcomes:
4 washing platforms:

1. 2009:
- 3taps
- 20% of the budget was spent locally, e.g local labour, renting local equipment, buying things from recycling depot, buying building material from local hardware shop, buying some food locally
- 7 community members temporarily employed
- students were involved in the design

2. 2011:
- 3 taps
- 22% of the budget spent locally
- 4-5 community members temporarily employed
- 26 students involved

2. 2012
- 3 taps
- 69% of the budget spent locally
- 4-5 community members
- 17 students involved

3. 2013:

- 3 taps
- 68 of the budget spent locally
- 4-5 community members
- 18students involved

4. 2014,15: Pavilions
- 1 tap per pavilion
- 36% of budget spent locally
- 4-5 community members employed
- 23, 28 students involved

The most successful ones were 2012, 2013 and that is specifically because we had the community members making a lot of the components for us on site. In terms of technology and innovation - it was using recycled materials. And using low tech construction. The two on sports field used more modern construction techniques which required less labour because it was more machine made. Less labour which means less people employed and less money spent. We wanted to try it and someone was willing to do it for free so we thought it was worth a try. In terms of speed and production it was very successful, but in terms of employment and spending money locally it was not that successful.

Who else is involved?
Other projects in local community: We also work with local school art project called Lalela, they work with 120 school children ranging from 5-18 years old. They make mosaics for us and then we build those into the platforms. We got put in touch with then through our local community liaison.
Private sector partners: engineering company that does engineering specifications for us for free
Other departments: The department of Geomatics helps us with the surveying of the sights (students).
Construction Economics and Management: They joined us on the soccer field, we gave them all the drawings and specifications and then they went and basically copy and pasted the pavilion in September.
Government: The department of Sports and Recreation, they contributed the land on which to build the pavilions.

How do you become aware of the unanticipated use of the platforms?
In 2012 the site had toilets, there was no tap and it was basically being used as a dumping ground. The students then did proposals for it and then a colleague and I then looked at all the projects, took what we thought were the most practical and ecstatically pleasing ideas from the different projects and assembled them. So we wanted to add stairs to create a level platform, to move the toilets to open the site up to the road so that it is not so concealed, so that it is safer. And then we wanted to add some wash tops. So what happens is people wash their clothes, they fetch water there, it becomes a public gathering space because there is not much formal public open space. People started having parties there over weekends and the kids play there while people are washing. So a lot of stuff happens that we did not anticipate with a lot of the platforms.
We have learned that over time. The different platforms are different, it is dependent on who lives around them. And whether those people take ownership of the platform and look after it in a way. Some that are more on the main street are taking quite a bit of a beating, because they are so extensively used. All the platforms are used by different groups of people at different points in time. During the day you might find people washing clothes with kids playing and in the late afternoon people sit there and chat or come and sit there with a beer. We have seen these things through observation and we have heard stories from people in the community. Some weekend nights people have had parties there, jumping on wash tops.
Because we noticed that kids play there, the 2013 platform also focused on designing components that might be interesting for kids to play with/on. While we were there we found out that one guy who lives next to the platform is a big soccer fan. So apparently on Saturdays he would push his TV out and all his friends would come watch the game on the platform. And we heard that on Sundays they have church services on the platform. So some really nice other uses came out of it that we did not plan for.

Any measuring of impacts through interviews etc.?
No we have not had funding/resources to go out and do it. We would like to, from a research point of view, determine who uses the platform and for what, and the change over time of the settlement because it is growing a lot. This needs funding, time and resources.

Challenges
Pre-casting/ pre-manufacture done because we only have 2 weeks on site, because the students want to go on vacation. So we start straight after exams finish, work for two weeks. We make a lot of things on site, but we try and prep as much as we can beforehand.

Shortcomings
Some of the students designed concrete blocks, but to make them lighter and use less concrete we put glass bottles in it. We then came up with the idea of getting local people to collect bottles in the community, so we paid people for each bottle they collected. We partnered with the company called Trash Back, they sponsored us a bottle cutting kit. Two local community members were nominated, we then trained them how to work with the bottle cutting kit and then we paid them for each bottle that they cut for us. We also showed them a lot of other things they could make out of the glass bottles. Then we showed them how to mix concrete, assemble the blocks and cast the blocks. And then we paid them per block. They made blocks for us and they ended up building the wall with the blocks they had made. When we were done, we gave them the tools, the bottle cutting kit, the moulds and some cement so they could potentially keep making blocks and pavers. Unfortunately, it did not happen. When we asked again later, the one guy had passed away and the

other had left the community. Even if they had stayed, it is not really our field of expertise to do mentoring and marketing. It almost needs another faculty/group to help to set up the little business and link them up with places that could sell the stuff and mentorship. To make that sustainable requires time, skills and other resources. This was one shortcoming that we realised. In terms of skills and employment, it is a very short-term intervention every year. We have not found someone to partner with who could look into that. The glass bottles were used, because we wanted to make use of recycled material. Some of the students suggested plastic bottles, but we thought glass would be more durable, this was however also wrong. Some of the people who held parties there started throwing out the glass bottles with rocks. We then paid someone to go chip them all off and plaster the wall, just for safety for kids. Unfortunately that was a learning curve.Getting local community members to make components was a very good process for everyone involved. Two of our students trained the community members how to use the bottle cutter, so the students became teachers, which was really nice. With another platform, there was an unemployed community builder who thought the students bricklaying and how to actually build. There is some teaching from both ends.

How would you describe the value in students having the opportunity to teach?
I think it is a skill that you learn and pick up as you go, especially as an architect, a lot of what you do is communication and transferring design/knowledge and explain it to other people. I think in terms of presenting your findings to someone is really good for students. It also builds their confidence. The interaction with local community members who for example is not from the same background as them, was also very valuable and rewarding for them on a personal level. This interaction with a more rural community is vital, because that is the bulk of the SA population, and for students to became aware first hand of that reality and how that influences them going forward in their careers. I have found that going into 3rd year and postgrad a lot of them end up having an interest in working in those sort of environments rather than doing an art gallery in the city for example. So it does create awareness, realisation of the need.

From the community side, to come into contact with young kids from various backgrounds, including students from overseas, who volunteer. And to see young students coming in and helping to do something is good. The students have to compile work experience reports in which they say what they have learned, what it meant for them. So the students give feedback but no in-depth community feedback. We do get feedback from our community liaison who lets us know whether it is being used if the people are generally pleased - basic level feedback.

Do you know how many people use the platforms?
No, I do have 2012 data from the department of solid waste on how many people there are per tap and per toilet. But we do not know per platform, it would be interesting to know what the radius of use is around each platform.

Who maintains the platforms?
There is no one who does maintenance. We have gone back to some of them. One of the plans is always that if we get funding, some of the students will go back and repaint or fix things on previous platforms. This is dependent on funding, time and the amount of students that we have. We are doing it on a small scale but there is no government/ community member that does the maintenance.

Why did you go from washing platform to pavilion?
We identified a site to do the platform. The students did designs. Then we want to the department who looks after that portion of land and halfway through they said no because they did not want to take ownership and do maintenance - that was quite late in the day a then we had to scramble to find another site. We got referred to the Sports and Recreation department, and then we suggested the pavilion. We gave the department all the drawings and specs so they could replicate it.

Which decisions have been critical to the innovation in terms of the outcomes?
- Pre-manufacturing of components and prototyping of those. And the potential of having those made locally, so the skill building and knowledge creation is quite exciting.
- The use of recycled content.
- Identifying possibilities in an informal settlement where you could do short sharp interventions that over time might improve a wider area.
- How to tweak a curriculum and stitch together different courses to enable this kind of intervention to happen?

What has been learned through this project about using student education as a platform for inclusive innovation?
Learning-by-doing approach. Recognising that there are skill that the students have and that there are resources that could be used to impact the broader community. Using students as a resource through teaching and then to create some sort of usable output in a non-academic community. Students can transfer their knowledge, older students can teach new students and students from different departments can teach each other. Making links across departments: Timing is usually the trick, in geomatics we use post-graduate students. We have to get them out soon enough so that it doesn't interfere with their other projects etc.

Main aim of the project, teaching, development...?
50/50 to teach the students and to have an impact in the community.

Criteria according to which projects/prototypes are graded?
Ergonomically suitable, practical to produce, robust, light enough to transport and work with, durable, recycled material.

Project D1

Interview date: Monday 25 April 2016

This project looks at healthcare communication. Sign support is mobile phone app that allows the pharmacist to "speak" to a deaf patient, where without assistive technology they would not be able to communicate with each other. If the patient doesn't understand the pharmacist there is no use for the medicine because it would mean that the patient would go away and not know how to take the medicine, or take it incorrectly which means they would not get better.

What were each of your roles?
Collaboration of expertise. One Industrial Engineer, one pharmacist and a computer scientist. We had to combine our expertise.

When did the project start?

2009: Version 1.0 Industrial Design Engineering (IDE) student from TU Delft identified the need that deaf people have to communicate in during medical consultations. He constructed a conceptual design for an app that would bridge the communication gap during a medical consultation between a deaf patient and a doctor. After analysis the team (industrial design student, computer science student, Bill, deaf) they found that communication during health consultation is too complex in the sense that it is not a dialogue that we could predict before the real-time interaction and there could be so many questions that we could predict. The app asked pre-recorded questions in sign language, to collect background data before the deaf person goes to the doctor. Then they would hand it to the doctor and the message was converted to text.

2010-2011: Version 2.0 A computer science student implemented the app on a Symbian phone. and Industrial Design Engineer student went back to the deaf community and realised that it would be better to focus specifically on pharmaceutical communication scenario. The Industrial Design Engineer did the conceptual design for pharmaceutical communication scenario.

2012: Pharmacist was added to project team. The application was implemented on an Android phone and was edited to comply to pharmaceutical practice. At this point team consisted of industrial design student, pharmaceutical lecturer, computer science student, research consultant that co-ordinate with the deaf community, and computer science lecturer.

2015: Testing Version 3.0 in real health facilities.

Critical Decisions made
To refocus on pharmaceutical scenario. And to add the pharmaceutical lecturer.

Project model
Computer science point of view: The ideal model that we would like to follow is a form of action research, where we are generating this with the community. The original idea for Sign support was not our idea it was something that came out of the community and then we've tried to called this community-based co-design. But the reality is that after the seed of the idea that came from the community it was mostly the academic team that did most of the design and then go back to the community to check it. To get feedback, to see if we are on track and if this is right or not. So in subsequent design phases the community was involved. From the design point of view: We nearly have 50% input from the deaf community. We first asked them what they wanted, and then how they wanted it illustrated. Whatever we came out with originated from the deaf people. The design involved a lot of participation from the deaf people. We have two user groups. The deaf people and the pharmacists. The pharmacist and the pharmacy students were also very involved.

Process of how the app got to where it is today

2012: IDE designed a y-frame of the app - shows multiple images of what the pages on the phone app would look like. The IDE and computer scientist changed design with the help of pharmacists in order to meet pharmaceutical regulations. We also studied dialogues between patients and pharmacists to see how it normally goes, what questions the pharmacist normally asks and pre-record these onto app - this was a 'hearing' patient. Then we predicted the interaction between the pharmacist and the patient. And then we came up with the design again. So the design was very iterative.

2013: First test (simulated test) in a dispensary at the pharmaceutical faculty. There were 8 pharmaceutical students and 8 deaf people who actually interacted via the mobile app: we received a generally happy response. There were some small technical difficulties such as the colour.
The users found the app to be user friendly. The deaf people said that they could understand the instructions communicated to them.

2015: Second test in actual hospital dispensary. Actual pharmacist used the app. The pharmacists were excited. Same outcomes as the simulated test. The test was almost exactly the same as the first test. The results lead to finalisation of experimental procedures.

What does it take to take this to the next level?

To move it to the next stage, I need to be free from academic duties. This type of work where you are interacting with a community and going into the field, you can't be having lectures in between and marking tests in-between. They can understand how to take the medication. But they still need more information. On what for example what kind of disease they have or what kind of medication they are taking. So they can communicate the instructions but we still need to add the required information. We would love to get the deaf

community to get more involved because based on experience we have seen that a project can actually be more rooted if the community is actually driving it. It is just not as easy. If we could get the authoring tool to a point where it is just plug and play and deaf people could get together with scenario experts and actually build their own scenarios it would be great.

How did you evaluate outcomes of the test?
Everything had to be evaluated from pharmacist and deaf people point of view. We had individual questionnaires and focus groups. First there was a focus group with everyone. Then individual questionnaires with each. We measure whether they could actually take their medicine by asking them the process of test re-call so for example "tell me how you take your medicine?". Then I could see whether they did actually understand the instructions. (Did not use actual drugs)

Budget up to this stage
The budget was about half a million rand per year (from 2009 onwards). This included everything. Bursaries for students, travel to deaf communities, interpreters, doing the videos, conferences, cell phones, laptops, and computers.

Main funders
Telkom centre of excellence program, Aria Technology (bring LG into SA), Department of Trade Industry, SANRAT funding.

Model used to take it to market
So far the app has been built on a series of prototypes built by students for their thesis' and for publications, whose main focus was not to produce a marketable tool. In order to take it to market we would have to hire full time researchers. Two post-docs and hire full time professional programmers. Whose main task is to produce clean code that is well documented. And to professional videos. It is open source. The model would be to provide everything for free. It would have to go to national health ethical clearance. We would look to in future provide a video relay service. If the deaf person is at home and requires some extra information. They could communicate to an interpreter via a video. The interpreter translates it to the pharmacist that then provides the information and the interpreter then sends a video back to the deaf person. There could be a revenue in this relay service - rich media content off which a mobile operator could make some money. We could also make some money. We would be giving them access to a lot of new customers. This has been done in other countries.

Who else was involved?
Tech transfer were not really involved - they helped with the layout of our proposal.
Different departments
UCT was involved - the first Dutch student was co-supervised by UCT lecturer.
TU-Delft co supervision of students. TU Delft sends students.
Government: Department of trade and industry
NGO: DCCT, National institute for the deaf contributes data, DEAFSA contributes new relationship with deaf community.

Spinoffs
[redacted] authoring tool: a tool that would allow one to build their own [redacted] app for different scenarios. Like Word/Power point.

How would you define success?
We will continue to be unsuccessful until the project is implemented and helping the deaf community.

Project D2

Interview date: Tuesday 26 April 2016

When was project initiated
The community driven approach to telecommunication started in April 2012.

What was your role in the project?
Main facilitator/driver. The architect of the project. I am a bridge between people who have a lot of knowledge. I had an idea and I have been lucky enough that other people with knowledge have been willing to collaborate in a free and voluntary basis.

What is/are the main objective/s of the project?
To create a model that can be replicated so that communities can set up their own telecommunication networks.

What is the nature of the project?
More of a hybrid (social enterprise). I struggle to see non-profit and commercial in two different categories. This project is a co-operative which is non-for-profit. It works using a utility model where everything that is generated by the project is re-invested in the project to continue increasing the services. So there is no profit in the business term of a board of members getting a return on investment, but it is commercial in the sense that the people are paying for the services that they are receiving.

Are there people who are earning in the project?
Yes, if the project is non-for-profit/ utility you pay the salaries of the people that are running the project, likewise in this project there they have decided that a percentage of the money that the co-operative is generating is used for their own 'incentive' (they call it incentive). An incentive for them to continue to participate. But in other terms this could be seen as the salaries paid by any other non-for-profit to be able to continue providing the services that they are providing. Therefore it is not a return on investment, rather a salary. The income of the co-operative is generated by charging phones. So there is a considerable amount of money generated from charging the phones of the community members.

Who are the stakeholders?
Faculty: Professors helping how to transform processes into publishable research
University from Spain
Administrative staff: management of funding and the budget
Students have been involved
Technology transfer office**:** help to transfer to a more replicable model and helped us to apply for some funds to the Technology Innovation Agencies.
Businesses:
Ellipses revelatory solutions which is a for-profit business that has been providing free advice because they believe in what we are doing.
Village Telco have been key on the technical part. We use their hardware and software. They have been providing a lot of support in terms of technical issues.
CSIR, Nicola

SIDA Nelson Mandela incubator has been providing the co-operative with some business and marketing training.
The Right To Know Campaign, helping us to translate our findings into knowledge that is more accessible to grassroots. Because everything that has been published is more for academics in a way.
Community members
Transcape NGO has their base in this community - there is some sort of office and links to the community
Government has participated as funding

Funding?
NRF
Telkom COE
European Commission

In which stages of the innovation process has university been involved?
Community networks have been implemented before in other countries. But it is innovative in this context. Co-design of the model not necessarily the technology. The sustainability model that takes into account the regulatory framework, the business model, the social context and the technology. We have developed the model. We have done a lot of evaluation.

Project Budget
CAPEX from the project is around R100 000. This is the costs of the hardware. It is difficult to provide a more refined budget of everything it would take.

Challenges?
The internet back hole. The offers from the internet providers in the area are based on the value of their assets (they are the only providers so they want to keep the monopoly so they overprice everything) rather than the cost of their solutions, so they are hindering the progress.

What have been the university contributions?
Main contribution has been funding. But a very important aspect was also the freedom and the confidence to go into the unknown trying to get this right. I think this approach to action research and learning-by-doing would be way stricter and reductionist in other places and wold entail setting the goals first and setting targets and KPI's. This is a process that we are all learning-by-doing and I think that the freedom to experiment and learn in such a way is very core to this department. I think this freedom is very important. It allows us to keep on learning and refining.

Outcomes so far?
1. Complexity: We are closer now to understanding how complex this is than we were in the beginning. We have looked at it from 4 different angles and involved quite a lot of people and disciplines. I think we are closer to understanding how to get it right, which we had no clue about 4 years ago.
2. We have managed to understand the context much better. The data that we have been able to produce in terms of communication patterns and communication expenditure in rural SA did not exist before. This context has now given us a lot of space to engage with other stakeholders at a different level for the future.
3. We have seen that it is possible. We have found barriers, and we are trying to overcome them. Hope has been created. I have been living there for 2 years and I have been attending the month meetings run held by the co-operative that has been running the project for the last 2 years. The commitment is seen in the people meeting every month since the beginning of the project, making plans forward, engaging looking at ways of doing things differently - this is probable the main

indicator. In a community like this where committees and any kind of external collaboration ends up being either over driven by external actors of fade out over time for one reason or another; after 4 years they have quite a lot of level of autonomy and commitment which gets them to meet every month and then a level of partners where if they want to add something, we can collaborate on a way to introduce it. *(Context is important: rural Transkei - they have been told to sit back, help is going to come. But they have taken things into their own hands, using technology. This is a radical change to their lives.)*

Assessment of the project?
The main service that they are using is the charging of phones. Initially the project was conceived as a way of reducing the cost of communications. So we went into assessing the possibility of setting up a wireless network and then using voice-over IP to reduce the cost of voice calls. Therefore, providing the cheapest alternative to making voice calls. The way we (us + community) went about it was to set up publically accessible analogue phones that were connected to the wireless routers. Initially they were able to make free calls inside the community. Once the regulatory and legal structures were in place, and the one was available these phones were able to call any other mobile phones in the country at a fraction of the cost they would usually pay.

There has been quite a lot of evaluation done on trying to understand what the patterns were and spending on communication before and after the phones were implemented (1 year later). We have evaluated if we had any impact in that regard - and we have not. The 12 analogues phones have not been used very much. There are many reasons for this. We understand the context much better now with regards to this as well - consumer habits and consumer dynamics. Also regarding how to change perceptions, for example, MTN is the first entrant in the market and it is used by 94% of the community, this is the same with milk, rice, maize meal and other products - and how to challenge that. We thought that by doing this from within we would be able to challenge these perceptions, we haven't. We understand the problems much better, we are still working on what the solutions are.

The evaluation assessments have been done by me (my phd)

We have made quite a bit impact on reducing the costs of charging mobile phones. In rural communities they have to pay to charge their phones. They pay a mark-up on their airtime. And we have been able to come up with some statistically representative sample numbers to show that from the money they spend 77% is airtime, and 22% is charging the phone and the mark-up. We have been able to reduce the charging costs quite a lot from the data we had before. So the people are able to charge their phones more often and that has quite a lot of impact because they receive more calls than they make so actually keeping the phone on at all times is more important than we think it is, because they also use it as a watch, flashlight, radio and to receive calls that are not only from their friends/family but also possible employment opportunities etc. People were able to charge their phones before but at double the price. The cost at th moment is R3 per phone. There are 8 chargers inside people's homes. We over dimensioned the solar powers that were powering the solar routers so there was some excess of power generated that they could use for whatever they wanted and they decided to use this power to charge mobile phones. And they decided to charge people to charge their mobile phones. So we might not have impacted the cost of communication but there has been a reduction in the cost of charging the mobile phones. If we see the cost of communication as the compound thing consisting of airtime, the mark-up and charging costs, then we have contributed to that. But then again there are some indicators that show the more you charge the phone the more airtime is used so it depends. There is very few data related to that in this country. In the past 3 years the co-op has collected R15 000 and more collectively, which would mean more than 5000 (R3x 5000) phones have been charged. (Started June 2013 - now)

Some other qualitative measures: the sense of ownership, commitment.

There was another project done that try to understand how the cheaper accessibility to internet could be used to access e-government services and he went there and trained gr 7-12 to actually apply for grants and he managed to assist 12 students from this community to get access to grants where in the past only 13% completed matric. These students went to university. In 2015 they completed their first year in university and they are undertaking second year.

We evaluated the technical part as well. Whether it could be managed locally and provide the services that they wanted.

And the social part in which the model could be translated to the community. The model is an ongoing thing. We are trying to provide Wi-Fi for the high school and the backpackers. And to set up some hotspots where students can go and do their homework.

Why are people not using the analogue phones?
In my perception people are not using them because they are fixed phones rather than mobile phones, people prefer to use mobile phones for privacy reasons. Their lack of numeracy together with the dynamic pricing that MTN uses etc giving 100% discount every 2 months. They do not know how to calculate how much they are spending so they think that MTN is cheaper that what the co-operative is offering. Whereas the co-operative is offering almost half the price.
The lack of marketing skills of the co-operative members. They are not able to market the solution. It is a question of not having the right product but also not the right marketing skills. We are working on introducing solutions for mobile phones, where those process could be applicable.

The model
The model consists of the analogue phones and charging stations. But it was not just the services, it was about trying to understand whether a rural community could actually legally provide this type of services and reduce the costs.

We managed to get the first double license exemption with regards to providing services on deploying infrastructure, so they are a legally constituted internet service provider within the SA regulation. This authority was given by the Independent Communication Authority of SA. So this is something that can be re-used. So we looked at the dimensions, the business model, legal framework in a way that the cost of maintaining the services was covered by the revenue generated by the services themselves. So there was evaluation on the economic part of the project as well. The co-operation is run by 10 people in the community - the 10 first houses chosen by the community in which to host these phone stations. So 10 representatives from these houses registered the co-operative. (Participation and bottom up)

What have been the critical success factors?
Trusting people - we have looked at things the other way around. We have looked bottom-up. And by trusting that people in isolated and remote communities could do this by themselves. And this brings many other spill over effects into the community and the process itself because it reduces costs, brings services that the community want in the way that the community does things. It is more difficult an takes more time to build up this trust and confidence in themselves but I think it is the way to go.

The cost of calls has been reduced. Calls to other MTN phones are 20c/min. We use a voice-over ip provider called Bitco for all calls except MTN and fro MTN we use a provider called Otel. It is cheaper because we use voice over ip technology rather than traditional GSM or copper wire technologies.

Critical choices i.t.o. outcomes?
Trusting people. It takes time to build trust and to refrain yourself from doing things yourself.
Being there, face to face communication. Respecting their decisions (I lived there for 2 years). This was critical to understanding their decisions.

Outcomes and outputs for university?
Publications,
R&D partnerships, we are invited to talks and research proposals, we have contacts at CSIR, UCT contacted us about collaborating with Barkley.
There was a replication of the project with the University of Namibia
There has been PhD's, masters
International collaboration with the University in Spain
Growing interest to replicate

What and how do you transfer?
The technical knowledge of how to do it and the potential that it has in the hands of a community based group. For them to take it forward and make t work. Practically this would consist of workshops. For example, in Namibia - the partnership with the community was done by the University of Namibia but then I went and I assisted them with the design of the network, with the training, with the materials. Providing support with the budget.
Transfer of the concept and the approach towards empowering people rather than having key holders.
Context specific: The regulatory part. And the services. What do they want the network for and how they going to make it happen in their own context?

Are there specific things that you put in place in terms of monitoring and evaluation?
Used both qualitative and quantitative.
Questionnaires looking at whether people are spending less/more on communication and whether they are using these phones less/more. I have tried to look at the impact on their broader lives by means of participative observation. I have seen that this way of empowering community members has transformed the way that Transcape NGO is engaging with the community - listening to them more and respecting their way of doing things. It has also influenced the way that they go about other externally initiated projects, in terms of the routines of taking minutes, asking for accountability, being transparent. This seed of a collaborative project could spill over into the way that other projects are run in this community in the future.

Critical factors in people's decision to use the service?

Cost, proximity, reliability
Reliability: other solar systems in community has no electricity after one cloudy day. It depends on how you design the solar panels. Bigger for more energy or you can use the cheapest thing and then you only have electricity while there is sun and maybe a little extra. Where our units could go for 3/4 days of autonomy - about 200Ah.

Appendix C: INTERVIEW RESULTS ON M&E

i. Interview results on M&E

This section will provide an overview of the results obtained from the 16 projects in our sample. We will start with a description of what was monitored, to what extent and by whom. Many of the projects in our sample have been implemented in a 'real-life' setting by means of a pilot project, but as these were not fully implemented it is not possible to measure impact yet (projects: B2, B3, B7, C4 and D1). This section will therefore only use data from the 12 UTIID projects that were successfully executed.

Projects	***Quantitative measures***	***Qualitative measures***	***How?***	***By who?***
A1	None	• Observations on the wear of structures. • Qualitative' data from students regarding whether the participation in such projects will impact the area in which they practice.	• Observations • Student reports	• Project champion • Students
A2	None	• Observations	• Mapping	• Community
B1	• Technical aspects: Dam area; Volume; Depth; Water quality: Water usage; Temperature;	• Qualitative data recorded after 1 year: (filled in for re-application) • Operational management and responsibility: responsible person; workers; operational project budget acceptance; own contributions. • Training status. • Support systems in place: Support of landowner; Mentorship; Access to infrastructure; Bank account.	• Technician visits site and checks technical aspects. • Each farmer must complete a yearly progress form.	• Technicians in project team and the board of directors evaluates progress form.
B4	None	• Observations • Feedback from teacher regarding use. • Questionnaire for the teacher. It was basically asking what worked and what did the children struggle with, simply from her observation while the children used the game.	• Questionnaire	• Project champion
B5	• Meter reading system: the amount of watts used. • Non-meter system measurements: Payments, amount of times the system was turned on and off, energy consumed.	• Community's like/dislike of system	• Meter reading systems. • Employed community members that track. • Questionnaires	• Project team

Monitoring and evaluation

B6	• Increase in matric pass rate (WCED: 11,9 % ; NCED: 7,9 %). • Attendance numbers at schools.	• Questionnaires for students, teacher and headmasters tracking whether the project was: A. Helpful with exam preparations; B. Whether it motivated learners to improve results, and C. Whether it encouraged learners to study further.	• Data from matric results. • Questionnaires	• Project team
C1	• Daily wage recording. • Daily usage of app.	• Use of and engagement with application. • GPS: Where it is used How it is used. • Types of phones used. • Power and politics. • Transparency of project. • Daily interactions between fishers and mentors.	• Use of software to track specific metrics. • Regular meetings with various groups involved	• Project monitors: individuals in the project team assigned to monitoring of interactions.
C5	• Keeping track of fires. • Loss of life, if any. • Nr of homes damaged.	• Qualitative feedback from communities where fires occurred. • Checklist: Are batteries being replaced "do people see value".	• Data from government. • Random checks. • Questionnaires and feedback after every fire.	• Government • Community liaison
C7	• Amount of taps implemented. • % of budget spent locally within the rural settlement. • Amount of community members employed. • Amount of students involved	• General Feedback gathered via community liaison.	• Keeping track of expenditure. • Community liaison • Interaction	• Project champion • Community liaison
D2	• Monitored the amount of money spent on communication and the costs of charging cell phones.	• The effect of community empowerment on the lives of the community members.	• Two sets of survey questionnaires. • Participative observations.	• Project champion

APPENDIX D: COMPONENT-FUNCTION ANALYSIS

i. Identification of function weaknesses

In Table 53, the indicators identified in Section 5.2 are used to analyse the system functions of each project in order to identify system weaknesses. A colour scale is used to visually represent the weaknesses/problem areas. Indicators that are absent to weak are classified as "not present" (-1), moderate to strong as "present" (+1) and indicators that are moderately present are classified as moderate and given a score of 0. We argue that this is sufficient as the aim is to help the projects identify the main problem areas. The table is highlighted according to a colour scale which is shown below the table. Blue (A) is the highest value in each function and as the value decreases the colours move to the right of the colour scale. Red therefore represents the most pressing areas that need attention. In the analysis that follows explanatory reasons (systemic problems) for the problem areas in each project is provided as well as suggestions (systemic instruments) of how to improve the components in order to improve project functioning.

Table 53: Functional analysis of 16 Case studies

Function	*Indicator*	Projects *Value*	A1	A2	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	C5	D1	D2
F1: Entrepreneurial activity	Project champion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Moderate form of project champion	0																
	No project champion	-1																
	Community involvement	1		1					1									
	Moderate community involvement	0			0	0				0		0		0	0	0	0	0
	No/weak community involvement	-1	-1				-1	-1			-1		-1					
	Experimentation	1		1	1	1			1				1	1	1		1	1
	Some extent of experimentation	0	0				0	0		0	0	0				0		
	No experimentation	-1																
	High Score	3	0	3	2	2	0	0	3	1	0	1	1	2	2	1	2	2
F2: Knowledge development	Knowledge infrastructure: Quality expertise, know-how and strategic information	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Moderate knowledge infrastructure	0																
	Weak/No knowledge infrastructure	-1																
	Research collaboration	1		1					1			1						1
	Community is moderately included in research	0			0	0	0	0		0	0			0			0	
	No research collaboration	-1	-1										-1		-1	-1		
	High Score	2	0	2	1	1	1	1	2	1	1	2	0	1	0	0	1	2

F3: Knowledge dissemination	Strong partnerships forming	1	1	1	1	1			1		1						1	1
	Moderate partnerships forming	0					0	0		0		0	0	0	0	0		
	Weak/No partnerships	-1																
	Demand-driven knowledge development	1		1					1			1					1	1
	Moderately demand-driven knowledge development	0											0		0	0		
	Knowledge development is top-down (not demand-driven)	-1	-1		-1	-1	-1	-1		-1	-1			-1				
	Space for knowledge dissemination	1		1	1				1	1	1						1	1
	Moderate space created for knowledge dissemination	0					0	0				0		0		0		
	No spaces created for knowledge dissemination	-1	-1			-1							-1		-1			
	High Score	3	-1	3	1	-1	-1	-1	3	0	1	1	-1	-1	-1	0	3	3
F4: Guidance of search	Targets set regarding the use of the technology	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1
	Vague targets for the use of technology	0	0					0										
	No targets, ad hoc implementation	-1																
	Well-articulated vision and belief in growth potential	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1
	Moderate belief in growth potential and some vision	0					0	0										
	No vision and growth potential	-1																
	Articulation of interest from marginalised community	1		1	1			1	1		1	1			1		1	1
	Some interest shown by marginalised community	0	0			0	0			0			0	0		0		

	No interest from marginalised community	-1																
	High Score	3	1	3	3	2	1	1	3	2	3	3	2	2	3	2	3	3
F5: Market formation	Incentives to promote market formation	1		1	1	1			1		1	1	1		1			
	Some incentives to promote market formation	0	0															0
	No incentives	-1					-1	-1		-1				-1		-1	-1	
	Business plan assessed?																	
	Yes	1		1	1	1			1		1	1	1	1	1			1
	No	-1	-1				-1	-1		-1						-1	-1	
	Existing market	1	1	1	1			1	1		1	1	1		1		1	
	New market must be created	0				0	0			0				0		0		
	Sufficient human infrastructure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
	Moderate human infrastructure	0																
	Insufficient human infrastructure	-1															-1	
	Sufficient policy infrastructure	1	1	1	1	1			1	1	1	1	1	1	1	1		1
	Moderate policy infrastructure	0					0	0									0	
	Insufficient policy infrastructure	-1																
	Sufficient technological infrastructure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Moderate technological infrastructure	0																
	Insufficient technological infrastructure	-1																
	Sufficient financial infrastructure	1				1		1	1	1	1		1		1			1

	Moderate financial infrastructure	0		0			0					0						
	Insufficient financial infrastructure	-1	-1		-1									-1		-1	-1	
	High Score	7	2	6	5	6	0	2	7	2	7	6	7	2	7	0	-2	5
F6: Mobilisation of resources	Sufficient financial infrastructure	1				1		1	1	1	1	1	1		1			1
	Moderate financial infrastructure	0		0			0											
	Insufficient financial infrastructure	-1	-1		-1									-1		-1	-1	
	Platform from which resources can be pooled	1			1	1			1	1	1		1	1	1		1	1
	Stand-alone project	-1	-1	-1			-1	-1				-1				-1		
	High Score	2	-2	-1	0	2	-1	0	2	2	2	0	2	0	2	-2	0	2
F7: Creation of legitimacy	Do project outputs have a good reputation?																	
	Yes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	No	-1																
	Are there agreements, memorandums set up to dictate the commitment of the university to the community?																	
	Yes	1		1	1	1			1	1	1	1	1	1	1	1	1	1
	No	-1	-1				-1	-1										
	Partnerships (formal/informal) forming.	1	1	1	1	1	1		1	1	1	1		1	1	1	1	1
	No partnerships	-1						-1					-1					
	No resistance to change	1	1	1	1	1					1	1	1	1	1	1	1	1
	Moderate resistance to change	0					0		0	0								
	Resistance to change	-1						-1										

	High Score	4	2	4	4	4	1	-2	3	3	4	4	2	4	4	4	4	4

Colour scale	A	B	C	D	E

ii. Analysis of each project to identify systemic problems and design systemic instruments

This section contains the individual analysis of each project. For each project, an explanation is provided for function weaknesses (identified in Table 53). This explanation is then categorised according to the type of systemic weakness that it is and then a systemic instrument is recommended to address this weakness. Table 54 -Table 63 show the analysis of each project respectively.

Table 54: Analysis of project A1

Project A1: Service learning project that entails the design and construction of structural interventions in rural community in SA.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Community unaware of the intervention in early phases.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of actors. • Induce and stimulate interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops held by the students in order to include community members. • Interactive actor involvement techniques: discussions between students and community members. • Construct cooperative research programmes or involve bridging institutions such as community liaison and local NGO's to improve the interaction between students and community. • Awareness campaigns; information campaigns.

F2: Knowledge development	x	• No/weak interaction between community and project team. • The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops held by the students in order to include community members. • New types of partnerships between university and local NGO/ university and community liaison. • Interactive actor involvement techniques: discussions between students and community members. • Construct cooperative research programmes by making community members a part of the research team. • Creating platforms for learning and experimenting, such as: training and education sessions; pilot projects; focus groups; feedback sessions. • Awareness campaigns; information campaigns. • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions.
F3: Knowledge dissemination	x	• No training/workshops held to disseminate knowledge. • Lack of meaningful interactions that could result in 'learning-by-interacting'. • Knowledge dissemination is top-down and not demand-driven; therefore, it is not 'inclusive'.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Vague targets for the use of technology, no M&E conducted beyond implementation. • Marginalised community show some interest, but also vandalise the structures.	**Infrastructure:** Quality **Institutions:** Presence	• Make sure that the infrastructure is of acceptable quality. • Stimulate the presence of hard and soft institutions.	• Set up port implementation monitoring plans to gather data on the use of the platforms in order to determine their value and adoption by the community. • Awareness campaigns; information campaigns to inform communities of the project and invite them to participate in the building process.

F5: Market formation	x	• No real incentive to promote market formation. • Unsustainable source of funding.	**Interactions:** Presence **Infrastructure:** Presence	• Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project. • Access to capital through grants/loans/funding; various business models.
F6: Mobilisation of resources	x	• Stand-alone project that does not form part of an innovation platform from which it can pool resources. • Unsustainable source of funding.	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors. • Stimulate and induce the presence of different infrastructures.	• Form innovation platforms within UCT where various researchers can share knowledge and lessons learnt as well as other resources. • Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy	x	• No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Set up a formal agreement or host meetings to discuss the expected commitment between the community and university.

Table 55: Functional analysis of Project A2

Project A2: Incorporated service learning into a module that entails community mapping. The students and community participate in the mapping of the informal settlement. The community then re-blocks the community so that the government can implement services.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity					

F2: Knowledge development					
F3: Knowledge dissemination					
F4: Guidance of search					
F5: Market formation	x	• Unsustainable source of funding: once-off donation from an NGO.	**Infrastructure:** Presence	• • Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project. The project aims to be independent of funds, but received donations from an NGO that made the re-blocking possible. Access to capital through grants/loans/funding; various business models.
F6: Mobilisation of resources	x	• Stand-alone project that does not form part of an innovation platform from which it can pool resources. Unsustainable source of funding.	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors. Stimulate and induce the presence of different infrastructures.	• Innovation platforms and collaborative research programmes with other departments at CPUT. Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy					

Table 56: Functional analysis of project B1

Project B1: SU Department of Aquaculture developed small-scale trout farming process that provided opportunity for farm workers to start their own trout farms without the ownership of land being a primary prerequisite.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors.	• Focus groups held with members from the marginalised community in order to get their inputs on the design of the device. • Awareness campaigns; information campaigns

				• Stimulate the presence of hard and soft institutions	
F2: Knowledge development	x	• The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Knowledge dissemination is top-down	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Focus groups; feedback sessions.
F4: Guidance of search					
F5: Market formation	x	• Unsustainable source of funding.	**Infrastructure:** Quality	• Stimulate and induce the presence of different infrastructures.	• Access to capital through grants/loans/funding; various business models.
F6: Mobilisation of resources	x	• Unsustainable source of funding.	**Infrastructure:** Quality	• Stimulate and induce the presence of different infrastructures.	• Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy					

Table 57: Functional analysis of project B2

Project B2: Point-of-use microfiltration system for production of clean water. The devices are cost effective and uses gravitational force instead of external energy sources for filtration.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops Awareness campaigns; information campaigns
F2: Knowledge development	x	• The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. Stimulate and induce interactions between diverse actors. Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Knowledge dissemination is top-down and not demand-driven. No space/opportunities created for knowledge transfer.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Training and education sessions; workshops; pilot projects. • Focus groups; feedback sessions; workshops. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Lack of awareness of the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.

F5: Market formation	x	• New market must be created	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
F6: Mobilisation of resources					
F7: Creation of legitimacy					

Table 58: Functional analysis of project B3

Project B3: Explore the use of technological support for school learners who require human readers during tests and examinations, in particular learners with reading disorders. The project replaced human readers with MP3 players that contained a pre-recording of the tests.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions. • Make sure that the infrastructure is of acceptable quality	• Include the teacher in the design process, allowing her to provide key inputs on what is needed and required. • Programme Evaluation methods and tools; forecasting; technology assessments; pilots: More attention needs to be given to the monitoring of the use of the game engine.
F2: Knowledge development	x	• The Community is not involved in the research process. The researchers are university staff members who executed the pilot project. Teachers and learners were not involved in the research process. They	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. Stimulate and induce interactions between diverse actors. Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). Awareness campaigns; information campaigns.

		only provided feedback afterwards.			
F3: Knowledge dissemination	x	• Weak partnerships forming. • No space/ opportunities created for knowledge transfer • Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Actors:** Capabilities **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Create spaces where actor capabilities can be improved. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO) • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Limited belief in growth potential: The project leader executed the pilot project and then stopped being involved. • Lack of awareness of the innovation amongst the members of marginalised communities: The technology proved to be very effective during the pilot study, but it was never adopted and used after the pilot study.	**Infrastructure:** Quality **Institutions:** Presence	• • Make sure that the infrastructure is of acceptable quality. Stimulate the presence of hard and soft institutions.	• Trend studies; programme monitoring methods and tools; surveys; questionnaires: Return to the schools after the pilot to see if they are using the technology and conduct surveys to determine whether school learners test writing experience has improved. • Awareness campaigns; information campaigns.
F5: Market formation	x	• No incentives for market formation. A new market must be created. There is only moderate financial infrastructure.	**Infrastructure:** Presence	• • Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project. Access to capital through grants/loans/funding; various business models.

F6: Mobilisation of resources	x	Stand-alone project that does not form part of an innovation platform from which it can pool resources. Unsustainable source of funding.	**Interactions:** Presence **Infrastructure:** Presence	Stimulate and induce interactions between diverse actors. Stimulate and induce the presence of different infrastructures.	Form innovation platforms between different departments at SU. Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy	x	No agreements/ memorandums that dictate the university commitment to the project, especially not after implementation. Some resistance to change: the stakeholders cannot fully utilise the technology.	**Institutions:** Presence **Actors:** Capabilities	Stimulate the presence of hard and soft institutions. Create spaces where actor capabilities can be improved.	Memorandum/agreement; obligations; articulation of commitment. Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. Host demonstrations of technology in order to transfer knowledge.

Table 59: Functional analysis of project B4

Project B4: The development and implementation of a generic development platform that enables any individual to easily develop individual therapy software (tools) for autism spectrum disorders, without resorting to extensive software development.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions. • Make sure that the infrastructure is of acceptable quality	• Include the teacher in the design process, allowing her to provide key inputs on what is needed and required. Programme Evaluation methods and tools; forecasting; technology assessments; pilots: More attention needs to be given to the monitoring of the use of the gmae engine.
F2: Knowledge development	x	• The teachers and school learners are not involved in the research process.	**Actors:** Presence **Interactions:** Presence	• Induce and stimulate the participation of several actors.	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.

			Institutions: Presence	• Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	
F3: Knowledge dissemination	x	• Weak partnerships forming. • No space/ opportunities created for knowledge transfer. • Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Actors:** Capabilities **Infrastructure:** Quality	• • Block or address ties that are either too strong or too weak. • Create spaces where actor capabilities can be improved. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Vague targets for the use of technology, no M&E conducted beyond implementation • Limited belief in growth potential.	**Infrastructure:** Quality **Institutions:** Presence	• Make sure that the infrastructure is of acceptable quality. • Stimulate the presence of hard and soft institutions.	• Strategies; evaluation methods and tools; forecasting; technology assessments; trend studies; surveys; questionnaires.
F5: Market formation	x	• No incentives for market formation.	**Infrastructure:** Presence	• • Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project.
F6: Mobilisation of resources	x	• Stand-alone project that does not form part of an innovation platform from which it can pool resources.	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors. • Stimulate and induce the presence of different infrastructures.	• Innovation platforms; collaborative research programmes; conferences.
F7: Creation of legitimacy	x	• No agreements/ memorandums that dictate the university commitment to the	**Institutions:** Presence **Actors:** Capabilities	• Stimulate the presence of hard and soft institutions.	• Memorandum/agreement; obligations; articulation of commitment. • Awareness campaigns; information campaigns.

		project, especially not after implementation. • Resistance to change. • Weak partnerships forming.	**Interactions:** Presence	• Block or address ties that are either too strong or too weak.	• New types of partnerships between public and private; various business models (non-for-profit, hybrid, for-profit); innovation platforms; collaborative research.

Table 60: Functional analysis of project B5

Project B5: The Research Centre is a collaborative research centre that consists of researchers from the university as well as co-researchers from the Enkanene community. The centre executes several informal settlement upgrading projects.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity					
F2: Knowledge development					
F3: Knowledge dissemination					
F4: Guidance of search					
F5: Market formation					
F6: Mobilisation of resources					
F7: Creation of legitimacy	x	• Some resistance to change: the community does not fully adopt all of the interventions.	**Institutions:** Presence **Actors:** Presence	• Stimulate the presence of hard and soft institutions. • Induce and stimulate the participation of several actors.	• Awareness campaigns; information campaigns. • Interactive stakeholder involvement techniques; workshops.

Table 61: Functional analysis of project B6

Project B6: This project explores alternative access to classroom teaching by exploring e-learning to promote inclusivity of students who have special learning needs that could be met by attending class "outside" of the physical classroom.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions. • Make sure that the infrastructure is of acceptable quality	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns. Programme. • Evaluation methods and tools; forecasting; technology assessments; pilots.
F2: Knowledge development	x	• The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Weak partnerships forming. • Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Lack of interest in the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.

F5: Market formation	x	• No incentives for market formation. • A new market must be created.	**Infrastructure:** Presence	• Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project. Access to capital through grants/loans/funding; various business models.
F6: Mobilisation of resources					
F7: Creation of legitimacy	x	• Some resistance to change: the community does not fully adopt all of the interventions.	**Institutions:** Presence **Actors:** Presence	• Stimulate the presence of hard and soft institutions. • Induce and stimulate the participation of several actors.	• Awareness campaigns; information campaigns. Interactive stakeholder involvement techniques; workshops.

Table 62: Functional analysis of project B7

Project B7: An intervention which seeks uses SU Telematics Division's interactive satellite platform to provide supplementary support for learners in underperforming schools, especially in rural communities of SA.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions. • Make sure that the infrastructure is of acceptable quality	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns. • Programme evaluation methods and tools; forecasting; technology assessments; pilots.
F2: Knowledge development	x	• The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors.	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). Awareness campaigns; information campaigns.

				• Stimulate the presence of hard and soft institutions	
F3: Knowledge dissemination	x	• Weak partnerships forming. • Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search					
F5: Market formation					
F6: Mobilisation of resources					
F7: Creation of legitimacy					

Table 63: Functional analysis of project C1

Project C1: This project looks at the fishery sector. It is a mobile phone app that allows the fisher community to communicate and share data with scientists and vice versa.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions. • Make sure that the infrastructure is of acceptable quality.	• Focus groups; feedback sessions; workshops. Awareness campaigns; information campaigns. • Programme evaluation methods and tools; forecasting; technology assessments; pilots.

F2: Knowledge development					
F3: Knowledge dissemination	x	• Weak partnerships forming. Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search					
F5: Market formation					
F6: Mobilisation of resources	x	• Stand-alone project that does not form part of an innovation platform from which it can pool resources.	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors. • Stimulate and induce the presence of different infrastructures.	• Innovation platforms; collaborative research programmes; conferences.
F7: Creation of legitimacy					

Table 64: Functional analysis of project C2

Project C2: Developed affordable heart valves in order to treat rheumatic heart disease with heart-valve surgery.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. Awareness campaigns; information campaigns. • Programme evaluation methods and tools; forecasting; technology assessments; pilots.

				• Make sure that the infrastructure is of acceptable quality	
F2: Knowledge development	x	• No/weak interaction between community and project team. • The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Knowledge dissemination is top-down and not demand-driven. • No space/ opportunities created for knowledge transfer.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Training and education sessions; workshops; pilot projects. • Focus groups; feedback sessions; workshops. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Lack of interest in the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
F5: Market formation					
F6: Mobilisation of resources					
F7: Creation of legitimacy	x	• No agreements/ memorandums that dictate the university commitment to the	**Institutions:** Presence **Actors:** Capabilities	• Stimulate the presence of hard and soft institutions.	• Memorandum/agreement; obligations; articulation of commitment. • Awareness campaigns; information campaigns.

		project, especially not after implementation. • Resistance to change. • Weak partnerships forming.	**Interactions:** Presence	• Block or address ties that are either too strong or too weak.	• New types of partnerships between public and private; various business models (non-for-profit, hybrid, for-profit); innovation platforms; collaborative research.

X

Table 65: Functional analysis of project C3

Project C3: This project developed and implemented a device that detects a change in temperature within a shack and sets off a network alert to protect against fires.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns.
F2: Knowledge development	x	• The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Weak partnerships forming. • No space/ opportunities created for knowledge transfer. • Knowledge dissemination is top-down and not demand-driven.	**Interactions:** Presence **Actors:** Capabilities **Infrastructure:** Quality	• Block or address ties that are either too strong or too weak. • Create spaces where actor capabilities can be improved. • Make sure that the infrastructure is of acceptable quality.	• Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Training and education sessions; workshops; pilot projects; focus groups; feedback sessions. • Host demonstrations of technology in order to transfer knowledge.

F4: Guidance of search	x	• Lack of awareness of the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
F5: Market formation	x	• No incentives for market formation. • A new market must be created. • Unsustainable source of funding.	**Infrastructure:** Presence	• Stimulate and induce the presence of different infrastructures.	• Grants/ loans/funding to incentivise UTIID project. Access to capital through grants/loans/funding; various business models.
F6: Mobilisation of resources	x	• Unsustainable source of funding.	**Infrastructure:** Quality	• Stimulate and induce the presence of different infrastructures.	• Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy					

Table 66: Functional analysis of project C4

Project C4: This project developed a mobile retinal camera to screen for diabetic vision impairment. It provides a cost-effective alternative to traditional methodologies.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns
F2: Knowledge development	x	• No/weak interaction between community and project team.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors.	• Focus groups; feedback sessions; workshops. Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.

		• The Community is not involved in the research process.		• Stimulate the presence of hard and soft institutions	
F3: Knowledge dissemination	x	• Knowledge dissemination is top-down and not demand-driven. • No space/ opportunities created for knowledge transfer.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak. • Stimulate and induce the presence of different infrastructures.	• Training and education sessions; workshops; pilot projects. • Focus groups; feedback sessions; workshops. Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search					
F5: Market formation					
F6: Mobilisation of resources					
F7: Creation of legitimacy					

Table 67: Functional analysis project C5

Project C5: The design and construction of water platforms in a rural community in SA. These platforms provide cleaner, more efficient and safer water collection areas. The platforms are used for water collection and clothes washing					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases. • Extent of experimentation is limited.	**Actors:** Presence **Institutions:** Presence **Infrastructure:** Quality	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns. • Programme evaluation methods and tools; forecasting; technology assessments; pilots.

				• Make sure that the infrastructure is of acceptable quality	
F2: Knowledge development	x	• No/weak interaction between community and project team. The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. Stimulate and induce interactions between diverse actors. Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination	x	• Knowledge dissemination is top-down and not demand-driven. • No space/ opportunities created for knowledge transfer.	**Actors:** Capabilities **Interactions:** Quality **Infrastructure:** Quality	• Create spaces where actor capabilities can be improved. • Block or address ties that are either too strong or too weak • Stimulate and induce the presence of different infrastructures.	• Training and education sessions; workshops; pilot projects. • Focus groups; feedback sessions; workshops. • Host demonstrations of technology in order to transfer knowledge.
F4: Guidance of search	x	• Lack of awareness of the innovation amongst the members of marginalised communities.	**Institutions:** Presence	• Stimulate the presence of hard and soft institutions.	• Awareness campaigns; information campaigns.
F5: Market formation	x	• No incentives for market formation. • A new market must be created. • There is only moderate financial infrastructure.	**Infrastructure:** Presence **Institutions:** Presence	• Stimulate and induce the presence of different infrastructures. • Stimulate the presence of hard and soft institutions.	• Grants/ loans/funding to incentivise UTIID project. • Access to capital through grants/loans/funding; various business models. • Awareness campaigns; information campaigns.
F6: Mobilisation of resources	x	• Stand-alone project that does not form part of an innovation	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors.	• Innovation platforms; collaborative research programmes; conferences. • Access to capital through grants/loans/funding; various business models.

		• platform from which it can pool resources. • Unsustainable source of funding.		• Stimulate and induce the presence of different infrastructures.	
F7: Creation of legitimacy					

Table 68: Functional analysis of project D1

Project D1: This project looks at healthcare communication. Sign support is mobile phone app that allows the pharmacist to "speak" to a deaf patient, where without assistive technology they would not be able to communicate with each other.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns.
F2: Knowledge development	x	• No/weak interaction between community and project team. • The Community is not involved in the research process.	**Actors:** Presence **Interactions:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate and induce interactions between diverse actors. • Stimulate the presence of hard and soft institutions	• Focus groups; feedback sessions; workshops. • Cooperative research programmes; feedback sessions; bridging institutions (community liaison, local NGO). • Awareness campaigns; information campaigns.
F3: Knowledge dissemination					
F4: Guidance of search					

F5: Market formation	x	• No incentives for market formation. • Insufficient human infrastructure: the project requires full time staff, but lecturers have other obligations as well. • Unsustainable source of funding.	**Infrastructure:** Presence Quality	• Stimulate and induce the presence of different infrastructures. • Make sure that the infrastructure is of acceptable quality	• Grants/ loans/funding to incentivise UTIID project and to employ full time staff members.
F6: Mobilisation of resources	x	• Unsustainable source of funding.	**Interactions:** Presence **Infrastructure:** Presence	• Stimulate and induce interactions between diverse actors. • Stimulate and induce the presence of different infrastructures.	• Partnerships that serves as enablers (funding). • Access to capital through grants/loans/funding; various business models.
F7: Creation of legitimacy					

Table 69: Functional analysis of project D2

Project D2: The design and development of a business case and mesh network in a remote rural community as a cost-effective alternative to traditional mobile networks.					
Function	***Problem areas***	***Reason for weak function***	***Systemic problems***	***Systemic instrument goals***	***Systemic instrument***
F1: Entrepreneurial activity	x	• Community absent in Design and Development phases.	**Actors:** Presence **Institutions:** Presence	• Induce and stimulate the participation of several actors. • Stimulate the presence of hard and soft institutions.	• Focus groups; feedback sessions; workshops. • Awareness campaigns; information campaigns.
F2: Knowledge development					
F3: Knowledge dissemination					

F4: Guidance of search					
F5: Market formation	x	• No incentives for market formation.	**Infrastructure:** Presence Quality	• Stimulate and induce the presence of different infrastructures. • Make sure that the infrastructure is of acceptable quality.	• Grants/ loans/funding to incentivise UTIID project.
F6: Mobilisation of resources					
F7: Creation of legitimacy					

APPENDIX E: INPUTS, OUTPUTS AND OUTCOMES TYPOLOGY

i. Developing Inputs Typology

Table 70: Inputs per Beneficiary

	Inputs per Beneficiary			
Project ID	Marginalised Community	Academics/ Researchers	Students	University
A1	Knowledge	Skills/Capabilities Expert advice Strategic leadership Design (inputs)	Skills/Capabilities Technical Knowledge Design Human infrastructure	Funding Facilities
A2	Funding Human infrastructure Skills/capabilities	Skills/Capabilities Expert advice Strategic leadership Design (inputs) Human infrastructure	Skills/Capabilities Technical Knowledge Design Human infrastructure	Facilities Equipment Funding
B1	Human infrastructure	Skills/Capabilities Expert advice Strategic leadership Technical Knowledge Business Knowledge Design	None	Facilities Equipment Human infrastructure
B2	Human infrastructure	Skills/Capabilities Expert advice Strategic leadership Design Technical Knowledge Business knowledge	Researchers Expert advice Pre-established relationship with community Social Knowledge Design (inputs)	Facilities Equipment Institutional infrastructure (Tech transfer) Business knowledge
B3	Human infrastructure Area to test Social knowledge	Skills/Capabilities Co-research Technical knowledge Design	None	Equipment Funding

B4	List of requirements	Skills/Capabilities Expert advice Technical knowledge Design (inputs)	Researchers Skills/Capabilities Human infrastructure Technical knowledge Design	Equipment Funding
B5	Co-researchers Skills/Capabilities Area to test Human infrastructure Pre-established relationship with community Design (inputs) Social knowledge	Skills/Capabilities Expert advice Strategic leadership Technical knowledge Design Human infrastructure	Researchers Skills/Capabilities Design (inputs) Technical knowledge	Funding Institutional infrastructure (Tech transfer) Business knowledge
B7	None	Skills/Capabilities Expert advice Strategic leadership Technical Knowledge Design	None	Funding Facilities Equipment Institutional infrastructure (Tech transfer)
B6	None	Skills/Capabilities Expert advice Strategic leadership Knowledge Human infrastructure Design	None	Facilities Equipment
C1	Co-researchers Skills/Capabilities Area to test Human infrastructure Pre-established relationship with community Social Knowledge	Skills/Capabilities Expert advice Strategic leadership Technical knowledge Design Human infrastructure	None	Facilities Equipment
C2	None	Skills/Capabilities Strategic leadership Funding Design Technical knowledge	Researchers Skills/Capabilities	Facilities Equipment

C3	Design inputs Area to test Community liaison Social knowledge	Skills/Capabilities Strategic leadership Expert advice Technical knowledge Design (inputs) Human infrastructure	Skills/Capabilities Strategic leadership Technical knowledge Design	Funding Facilities Equipment Institutional infrastructure (Tech transfer) Business knowledge
C4	Area to test	Funding Skills/Capabilities Strategic leadership Expert advice Technical knowledge	Researchers Skills/Capabilities	None
C5	Skills/Capabilities Human infrastructure	Skills/Capabilities Strategic leadership Technical Knowledge Design	Skills/Capabilities Technical knowledge Design (inputs)	Skills/Capabilities
D1	Expert advice Design (inputs) Social knowledge	Skills/Capabilities Strategic leadership Expert advice Technical knowledge Design (inputs)	Human infrastructure Skills/Capabilities Strategic leadership Technical knowledge Design Social knowledge	Funding Facilities Equipment
D2	Human Infrastructure Expert advice Facilities Pre-established relationship with community Social knowledge Business knowledge Design (inputs)	Skills/Capabilities Strategic leadership Expert advice Technical knowledge Social Knowledge Human infrastructure Design	None	Institutional infrastructure

Table 71: Summarised inputs per beneficiary

Input Typology	*Marginalised Community*	*Academics/ Researchers*	*Students*	*University*
Funding	1	2	0	8
Skills/Capabilities	4	16	9	0
Technical knowledge	0	13	7	0
Social knowledge	6	1	2	0
Business knowledge	1	2	0	3

Expert advice	2	13	0	0
Strategic leadership	0	14	0	0
Human infrastructure	7	6	4	0
Facilities	1		0	10
Equipment	0	0	0	11
Institutional infrastructure	0	0	0	5
Pre-established relationship with community	4	0	1	0
Design	0	10	5	0
Design (inputs)	4	5	3	0

Table 72: Input typology per beneficiary group

Beneficiaries	***Inputs***
Marginalised Community	• Human Infrastructure • Social knowledge • Skills/Capabilities • Pre-established relationship with community • Design (inputs)
Academics/ Researchers	• Skills/Capabilities • Strategic leadership • Technical knowledge • Expert advice • Design • Design (inputs) • Human Infrastructure • Business knowledge
Students	• Skills/Capabilities • Technical knowledge • Design • Design (inputs) • Human infrastructure
University	• Equipment • Facilities • Funding • Institutional infrastructure • Business knowledge

ii. Developing Outputs Typology

Table 73: Outputs per UTIID project

Project ID	*Outputs for marginalised community*	*Outputs for academics*	*Outputs for students*	*Outputs for university*
A1	Built interventions Re-blocked community Designs Water platforms	PhD's, Research publications, Conference presentations, R&D partnerships,	Practical experience Skills/Capabilities Course credits	PhD's Research publications Research presentations R&D partnerships Student education Competencies Research networks Good reputation
A2	More practical layout of settlement Re-blocked community with services Data required in order to demand services	Conference presentations Award at international conference	Practical experience Skills/Capabilities Course credits	Good reputation Research presentations
B1	Improved standard of living: income per capita, nutritional status Skills/Capabilities Employment opportunities	Development and implementation of a technology Conference presentations	Masters projects	Good reputation Conference presentations Patent
B2	Access to clean water	Development and demonstration of a technology	Masters projects	Patent
B3	Alternative mode of education (more inclusive)			
B4	Alternative mode of education (more inclusive)		Masters projects Conference presentations	

B5	Employment opportunities Skills/Capabilities Improved standard of living Access to solar energy Clean water and sanitation Skills/Capabilities	Publications Conference presentations R&D partnerships	Masters projects PhD's Publications Conference presentations	Flagship project of provincial government Good reputation CSR Patents
B7	Supplementary educational support	Conference presentations		CSR Conference presentations
B6	Alternative mode of education (more inclusive)	Conference presentations R&D partnerships		Good reputation Conference presentations
C1	Access to information Platform to share information	Conference presentations Publications R&D partnerships	Masters projects	Patent
C2	Affordable medical treatment Inclusive medical treatment	Publications	Masters projects PhD's	Good reputation
C3	Fire alert system	Development and implementation of a technology Publications	Masters projects	Patent Publications
C4	Affordable medical treatment	Publications	Masters projects PhD's	Publications CSR Good reputation
C5	Built interventions Water platforms	Conference presentations	Practical experience Skills/Capabilities Course credits	CSR
D1	Inclusive medical treatment	Conference presentations Publications	Masters projects PhD's Conference presentations Publications	Conference presentations Publications

D2	Affordable communication Access to internet Affordable cell phone charging points	Conference presentations Publications R&D partnerships Replication of projects at the University of Namibia	Masters projects PhD's Conference presentations Publications	Conference presentations Publications R&D partnerships Good reputation

Table 74: Output typology per beneficiary group

Beneficiaries	***Outputs***
Marginalised Community	• Access to information • Alternative modes of education (more inclusive) • Built interventions • Clean water and sanitation • Designs • Electronic communication • Employment opportunities • Improved nutritional status • Inclusive medical treatment • Increased income per capita • More practical layout of settlement • Skills/ Capabilities
Academics/ Researchers	• Awards • Conference presentations • Masters • PhD's • Publications
Students	• Conference presentations • Masters • PhD's • Publications • Practical experience • Course credits
University	• Awards • Conference presentations • Masters • PhD's • Publications • Good reputation • CSR

iii. Developing Outcomes Typology

Table 75: UTIID projects outcomes typology

Outputs	
General outputs	**Academic outputs**
Access to information	Awards
Alternative modes of education (more inclusive)	Conference presentations
Built interventions	Good reputation
Clean water and sanitation	Masters
Designs	Patents
Electronic communication	PhD's
Employment opportunities	Publications
Improved nutritional status of community members	R&D partnerships
Inclusive medical treatment	
Increased income per capita	
More practical layout of settlement	
Skills/Capabilities	

Table 76: Project outcomes

	Outcomes of the UTIID projects			
Project ID	**Outcomes for marginalised community**	**Outcomes for academics**	**Outcomes for students**	**Outcomes for university**
A1	Built capital: Buildings Water and sanitation Cohesive and secure environments	Academic capital: Degrees Social capital: Trust Built capital: Contribution to regional governance and planning	Human capital: Learning Education Experiences Social capital: Trust	Social capital: CSR Academic capital: Degrees

Inputs, outputs and outcomes of UTIID projects

A2	Built capital: Water and sanitation Buildings Roads Contribution to regional governance and planning Cohesive and secure environments Human Capital: Learning Experiences Leadership development Financial capital: Savings scheme Social capital: Sense of belonging Trust Political capital The ability to influence the distribution of resources. Connections Voice	Academic capital: Publications Awards Social capital: Trust Political capital: Connections	Human capital: Learning Education Experiences Employability of graduated university students Social capital: Trust	Social capital: CSR Academic capital: Degrees Conference presentations
B1	Built Capital Machinery Human Capital Investments in people Learning Education Leadership development Financial Capital Funding Grants and Loans Investments Social Capital Trust Business capital Established businesses/corporations	Human Capital Leadership development Social capital: Trust Academic capital Conference presentations Business capital Established businesses/corporations		Social capital: CSR Academic capital: Degrees Conference presentations Business capital Established businesses/corporations
B2	Built capital: Water and sanitation Human Capital Improved health	Academic capital: Development and implementation of a technology Business capital: Established businesses/corporations	Human capital: Employability of graduated university students Academic capital: Networks	Social capital: CSR Academic capital: Degrees Business capital: Patents Established businesses/corporations
B3	Human Capital Learning Education	Academic capital: R&D partnerships	None	None

Inputs, outputs and outcomes of UTIID projects

B4	Human Capital Learning Education Built capital Machinery	Academic capital: Conference presentations R&D partnerships	Human capital: Learning Employability of graduated university students Academic capital: Conference presentations R&D partnerships	Academic capital: Conference presentations R&D partnerships Degrees
B5	Built Capital Water and sanitation Buildings Electronic communications Cohesive and secure environments Social Capital Sense of belonging Trust Networks Community capacity building Human Capital Jobs created Learning Education Leadership development Improved health Faster and wider diffusion of new knowledge Financial capital Higher earnings/cost savings Political capital The ability to influence the distribution of resources. Connections Voice	Built Capital Contribution to regional governance and planning Human capital Learning Experiences Leadership development Business capital Established businesses/corporations Academic capital: Conference presentations R&D partnerships Degrees Publications Social capital Community capacity building Trust	Human capital Learning Experiences Leadership development Academic capital: Conference presentations R&D partnerships Degrees Publications Social capital Community capacity building Trust	Social capital: CSR Academic capital: Conference presentations R&D partnerships Degrees Publications Business capital: Patents Established businesses/corporations
B7	Built Capital Machinery Human capital Learning Education	Human capital Learning Leadership development	None	Social capital: CSR
B6	Human capital Learning Education Social capital: Sense of belonging	Human capital Learning Leadership development	Human capital Learning Education Social capital: Sense of belonging	Academic capital Degrees

Inputs, outputs and outcomes of UTIID projects

C1	Built capital: Electronic communications Human Capital Faster and wider diffusion of new knowledge Social capital Trust Networks Financial capital: Higher earnings/cost savings	Human capital Learning Financial capital Grants and Loans Investments Business capital Established businesses/corporations	Human capital Learning Degrees	Social capital: CSR Academic capital Degrees Business capital Established businesses/corporations
C2	Built capital: Improved health care facilities/treatment Human capital Improved health	Human capital: Learning Academic capital: Development and implementation of a technology Conference presentations Publications R&D partnerships	Academic capital: Degrees Conference presentations Publications R&D partnerships	Academic capital: Degrees Conference presentations Publications R&D partnerships
C3	Built capital: Machinery Human capital Improved safety Learning Leadership development Social capital Networks	Human capital: Learning Academic capital: R&D partnerships	Human capital: Learning Academic capital: Development and implementation of a technology Conference presentations Publications R&D partnerships Business capital: Established businesses/corporations Patent	Academic capital: Degrees Conference presentations Publications R&D partnerships Business capital: Established businesses/corporations Patent
C4	Built capital: Improved health care facilities/treatment Human capital Improved health	Human capital: Learning Academic capital: Conference presentations Publications R&D partnerships	Academic capital: Degrees Conference presentations Publications R&D partnerships	Academic capital: Degrees Conference presentations Publications R&D partnerships

C5	Built capital: Buildings Water and sanitation Cohesive and secure environments	Academic capital: Degrees Social capital: Trust Built capital: Contribution to regional governance and planning	Human capital: Learning Education Experiences Social capital: Trust	Social capital: CSR Academic capital: Degrees Conference presentations
D1	Built capital: Electronic communications Improved health care facilities/treatment Human capital Improved health	Human capital: Learning Academic capital: R&D partnerships Financial capital: Funding Grants and Loans	Human capital: Learning Academic capital: Development and testing of a technology Conference presentations Publications R&D partnerships	Academic capital: Degrees Conference presentations Publications R&D partnerships
D2	Built capital: Electronic communications Human capital Learning Leadership development Jobs created Social capital Networks Financial capital: Higher earnings/cost savings Business capital: Establised businesses/corporations	Human capital: Learning Academic capital: R&D partnerships Degrees Financial capital: Funding Grants and Loans	None	Academic capital: Degrees Conference presentations Publications R&D partnerships