A functional approach to guide sustainable innovations in the sanitation chain

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A functional approach to guide sustainable innovations in the sanitation chain

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I. Preface

Several personal motives influenced me on my way towards graduation. My interest in the challenge of bringing technological and socio-economic aspects together was an important driver throughout my studies. Triggered by my first academic coach I developed a keen concern for development-related topics because possibly no other field offers such a richness of different disciplines, cultures, actors and approaches. Moving into the field of sanitation was however more a coincidence than conscious choice; an experience that I share with many other people in the field. After getting assigned to research the business opportunities for portable toilets in India in summer 2013, I realised that sanitation is not only a very important, but also a very interesting and multifaceted field of research. Introducing an innovative theoretical concept to this field seemed like an exciting challenge. This led to the choice of my graduation topic and WASTE as an organisation to perform this study for.

Working on this thesis in the Netherlands and Malawi for the last months was a very enjoyable and valuable learning experience for me and I am very thankful for all the people that supported me along this journey. I would like to thank the whole WASTE team for creating a friendly and open atmosphere and providing a great environment for inspiration, research and new ideas. Special thanks go to my supervisors in the Netherlands and Malawi, Kim Visser and Joseph DeGabriele who supported me a lot during the practical phase of the research. I would furthermore like to thank my first academic supervisor Henny Romijn for all the inspiration, support and the steady supply of reading material as well as my second supervisor Joost Wouters for giving useful feedback, bringing in a different perspective. Finally, I would like to thank all my family and friends for their support and their refreshing discussions about sanitation-related matters in the last months.

I hope that you enjoy reading this report and that it will give you some useful new insights!

Benedikt Wirmer,

Utrecht, 2014

II. Abstract

This report investigates the use of the Functions Approach to Innovation Systems (FIS) in the context of guiding innovations in the sanitation chain of the global South. It was recognised that the FIS may be useful to guide such innovation projects, but that its application in this context has not been adequately addressed yet. By exploring the FIS in two cases, emergency sanitation and faecal sludge treatment with houseflies in Malawi, new insights were gained. Based on the findings, a manual for practitioners was designed. Furthermore, recommendations for further research and development of the FIS are given.

III. Introduction

The lack of access to basic sanitation services is one of the pressing issues in developing countries. Poor hygienic conditions lead to spread of diseases and have a serious impact on people's health, productivity and quality of life. Furthermore, inadequate disposal of human waste is a serious threat to the environment and the often scarce drinking water resources. However, still 2.6 billion people worldwide, that is 40% of the world's population do not have access to basic sanitation (UNICEF and World Health Organization, 2012).

For more than 30 years, the non-profit organisation WASTE helps people to improve the quality of their own life by supporting organisations, companies and cities in developing countries to build a functioning market for sanitation and sanitation services. Since two years, WASTE is also offering its services to the European private sector because its innovative solutions have the potential to solve challenges in sanitation in a profitable and sustainable way. It is challenging to initiate and guide such innovation projects and WASTE is still in a learning process regarding this. Transition studies, in particular the Functions Approach to Innovation Systems (FIS) may be useful to guide such innovation projects in a more efficient and successful way. Until now, the experience of using the FIS in this context is however limited and has to be further explored.

This research aims to fill this gap by exploring the application of the FIS in the WASTE context. I will show if WASTE may indeed benefit from using the FIS approach for guiding sustainable innovations in the sanitation chain. Based on findings in literature and with two case studies I will try out and adjust the approach for its use within WASTE. Furthermore, I will design a manual that enables WASTE analysts to use and improve the approach in future innovation projects. Finally, I will reflect on this research, point out implications for theory and give recommendations for future research.

Report outline

The first chapter introduces into the background of the research. The organisation WASTE is presented and the surrounding problem field is analysed, putting the research into a real-world context. The second chapter begins with presenting the findings of the orientation phase at WASTE. This leads to the research assignment and the research questions. Finally, the methodology that is used in order to fulfil the research objectives is explained. Chapter three encompasses the literature review. It presents relevant aspects of scientific literature related to Technological Innovation Systems and the functions approach and puts them into context of the research. Chapter four explains methodological aspects for the case studies that follow in chapter five and six. These cases are based on numerous in-depth interviews with experts, meetings, site visits and extensive desk research and illustrate the use of the FIS in the sanitation context. Chapter seven explains the design choices that led to the final design of the WASTE FIS manual, based on the findings in the case work and literature. The concluding chapter contains a reflection on the research, implications for theory and recommendations for future activities.

IV. Executive summary

The Dutch organisation WASTE enables people to improve the quality of their own life by supporting them in setting up sustainable sanitation solutions. With its dedicated initiative "Sanitation Window", WASTE is also increasingly involving the European private sector in this task as it is seen to have the potential to offer innovative, sustainable sanitation solutions.

An analysis of WASTEs recent activities revealed that their innovation projects are mostly guided in an ad-hoc manner by individual WASTE consultants. This proved to be challenging in many situations as it was difficult to motivate choices and strategies towards stakeholders such as clients or funding partners. Furthermore, it was difficult to turn experiences into organisational knowledge for future innovation projects. It was concluded that a more structured and transparent approach may help to tackle these challenges. After reviewing several existing concepts from the field of transition studies, the Functions Approach to Innovation Systems (FIS) has been identified as a suitable starting point. In contrast to other approaches it is specifically designed for practitioners and aimed at extracting practical guidelines. However, there is a lack of experience of using the FIS in the context of development issues and an organisation such as WASTE. This led to the following main research question:

How can the functions approach to innovation systems contribute to a sustainable introduction of innovations into sanitation chain settings of the global South?

In order to answer this research question, a design-based approach was used. Core of this approach is conducting two FIS analyses with cases based on current WASTE innovation projects. Both cases were selected with the aim to cover a wide range of typical WASTE innovation projects. The first case deals with a more general innovation setting and analyses the barriers and opportunities in the Emergency Sanitation sector. The second case investigates the barriers and opportunities for faecal sludge treatment with house flies in Malawi and thereby focusing on a specific product and location. By exploring the use of the FIS approach with these real-life cases in an iterative way, new insights were gained. Based on these insights, a WASTE FIS manual was designed that allows WASTE consultants to use and further develop the FIS approach as a tool to guide innovation projects. The resulting case descriptions serve furthermore as show case examples, illustrating the use of the FIS in the WASTE context. Among others, the following key findings were made:

- Overall, the FIS can be indeed useful to guide WASTE innovation projects
- It is essential to include the assessment of the desirability of an innovation into the FIS
- Anticipated functional configurations are good means to select and prioritise the blocking and inducement mechanisms that should be addressed

Furthermore, various opportunities for further research could be identified. Although a context-specific approach for dealing with the desirability of an innovation was developed, the FIS may still need a more generic concept to deal with desirability of an innovation, especially if the FIS is used for intervention. The link between the different components of the FIS was often not clear, in particular between the structural analysis and the functional analysis. Future research should aim at making these links more explicit. This study revealed furthermore, that information related to the functional analysis can be quite multi-layered and may benefit from better structuring. Also assessing the performance of a function from an entrepreneurial perspective shows room for improvement. Insights from other disciplines may provide useful contributions for this. Finally, no satisfying answer to the question of sustainability could be given. More research and practical insight is needed to find ways to ensure the long-term sustainability of an innovation project.

V. Table of contents

I. Preface I
II. Abstract II
III. Introduction III
IV. Executive summary IV
V. Table of contents V
VI. List of abbreviations VI
1 Context of the study 1
1.1 WASTE 1
1.2 The problem field 2
2 Research assignment and methodology 5
2.1 The SAWI way of working 5
2.2 Research assignment 6
2.3 Methodology 8
3 Literature review 11
3.1 Technological Innovation Systems 12
3.2 Functions approach to innovation systems 14
3.3 The FIS scheme of analysis in detail 15
3.4 Summary 22
4 Methodological aspects of the exploration phase 23
5 Opportunities and barriers for innovations in the emergency sanitation sector 25
5.1 Sources of information 25
5.2 What is emergency sanitation? 26
5.3 The FIS analysis 26
5.4 Summary and methodology-related key lessons 40
6 Opportunities and barriers for JAGRAN in Malawi 42
6.1 Sources of information 42
6.2 The JAGRAN Musca Domestica concept 42
6.3 Country brief Malawi 43
6.4 The FIS analysis 44
6.5 Summary and methodological key lessons 57
7 Design of the WASTE FIS manual 59
8 Reflection and conclusion 63
References 65
Appendix 1: Overview of interviewees i
Appendix 2: WASTE manual for the FIS approach ii

VI. List of abbreviations

BMGF	Bill & Melinda Gates Foundation
BSF	Black Soldier Fly
ES	Emergency Sanitation
ESS	Emergency Sanitation Sector
EU	European Union
FIS	Functions Approach to Innovation Systems
GNI	Gross National Income
GPB	Pound Sterling
HIV	Human Immunodeficiency Virus
IFRC	International Federation of Red Cross and Red Crescent
JMD	JAGRAN Musca Domestica
KD	Knowledge Development
MLP	Multi-level Perspective
NGO	Non-governmental Organisation
NL	the Netherlands
PUM	Programma Uitzending Managers
R&D	Research and Development
SAWI	Sanitation Window
SNM	Strategic Niche Management
SRU	Shelter Research Unit
SuSanA	Sustainable Sanitation Alliance
TIS	Technological Innovation System
TM	Transition Management
UK	United Kingdom
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USA	United States of America
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation

1 Context of the study

Before the problem and the research question of this research are introduced, this chapter gives an overview of the various drivers that underlie this study. After introducing the organisation WASTE on which this research is focused, I will give an overview about the underlying global trends that lead to the relevance of this research.

1.1 WASTE

WASTE is a non-profit consultancy firm with more than 30 years of experience in sanitation, solid waste and sustainable financing in the global South. Driven by the vision of enabling people in urbanized areas having a dignified life in balance with their environment, WASTE has been contributing to numerous development projects. Most of the 16 employees are consultants with a background in the NGO world and the private sector. The organisation offers a wide range of services to various stakeholders.

- Management of multi country programmes on sanitation and waste management
- Evaluation studies for projects and programmes
- Baseline studies on solid waste and sanitation situation for cities
- Study visits in the Netherlands and neighbouring countries

One of its trademarks is WASTEs systemic framework of integrated sustainable waste management (ISWM) providing a practical approach and methodology that supports the improvement in urban environmental services and value chains. Core competence of the sanitation group is decentralised sanitation with a focus on nutrient recycling and closing loops under consideration of aspects of finance, institutions, environment, technology and society (FIETS). A comprehensive framework comparable to ISWM is under development. The Dutch government is currently the most important source of funding for its projects but other stakeholders become increasingly important.

The sanitation chain is an integrated concept that consists of the five steps production, capture, collection & transport, treatment or disposal and re-use. It can be also interpreted as value chain, where human excreta are seen as potential resource for valuable products such as biogas or fertiliser for example.

Figure 1.1 The sanitation chain (WASTE, 2013)

Aim of this research is to support the sanitation group with their ongoing efforts to systematise their existing knowledge to products. A focus will be put on the recently started joint initiative “Sanitation Window” (SAWI) that aims to connect the Dutch and European private sector with sanitation chains in WASTEs target markets. SAWI was established because WASTE and its partner Aqua for All often encountered opportunities where innovations from the private sector of developed countries could have had a great impact but they did not find their way towards low-income markets in Africa, Asia or Latin America yet. The organisation believes that sanitation problems in emerging markets can be solved in a profitable and sustainable way. Interacting with the European private sector requires however the ability of WASTE to utilise and apply its existing knowledge to this new context. A continuous development of SAWIs approaches is therefore essential in order to deliver high quality

results to its clients in an efficient way and to develop SAWI towards a successful and self-sustaining part of the WASTE portfolio.

1.2 The problem field

This section describes the underlying global issues and trends in development and sanitation that are the main driving forces behind WASTEs past and recent engagement. Altogether they can help to identify and delimit the problem field this research is concerned with.

One of the main driving forces is the steep increase of population in developing countries along with a rapid urbanisation that has led to a variety of problems. Over one billion people live in slums and the cities in developing countries are expected to absorb 95% of the urban population growth within the next two decades (United Nations Human Settlements Programme, 2013). While rural areas experienced a great deal of progress in gaining access to improved sanitation, the number of unserved people in urban areas has grown by 183 million since 1990 to a total of 714 million people without access to improved sanitation (UNICEF and World Health Organization, 2012). Poor sanitation is not only a health risk on its own but also puts the often scarce water resources at risk. Increasing the access to improved sanitation is therefore necessary in order to ensure environmental sustainability and to improve people's health, productivity and quality of life.

Local and international development-related organisations such as WASTE are important actors for improving sanitation where it is needed most. They are setting up initiatives and conduct and coordinate projects in order to establish improved sanitation in a certain area. In the past, these organisations have been often relying on public resources such as (local) subsidies or development funds. The recent emergence of initiatives such as SAWI and others[1] shows that this approach is increasingly complemented by an involvement of the private sector. Organisations increasingly utilise the potential of the (Western) private sector to support them in their mission and as a complement to their existing stakeholders.

On the other hand, also the private sector shows an increasing interest in doing business in low- and middle-income settings. Triggered by high growth rates in many developing countries and the emergence of a "doing business with the poor" paradigm, companies are increasingly seeing the so-called base of the pyramid (BoP) as an attractive market opportunity (Prahalad & Hammond, 2002). It poses as a promising complement to saturated, competitive and often stagnating home markets in developed countries. Another development is the increasing popularity of so-called social businesses. The concept was first defined by Yunus (2007) as a company designed to address a social objective while generating a modest profit that is used to expand and improve its social mission.

To summarise, one can observe that development organisations as well as Western businesses themselves see an increasing role for the private sector in BoP settings. The recent emergence of initiatives such as SAWI indicates that this development is also taking place in the sanitation sector. These initiatives and their clients share the common belief that poor sanitation is a problem that can be solved in a responsible, sustainable *and* profitable way. Observing this development, the following question arises:

Why is there actually a perceived need for dedicated initiatives such as SAWI in order get the private sector involved into the development of the sanitation sector?

[1] During the conceptual phase of SAWI the following initiatives with a similar focus have been identified as part of a competitor and partner analysis: IDEO.org. Sanitation Ventures, BoP Innovation Centre, Proportion Foundation, Micro Water Facility.

By exploring the expressed needs and expectations of the different SAWI stakeholders, I try to identify the underlying problems that triggered the initiation of SAWI. One can basically distinguish between the two stakeholder groups "supply" and "demand". The supply-side can be defined as European companies and social businesses that are interested to bring a certain technology or product to a developing market. The demand-side is represented by WASTE and its network of international and local stakeholders.

Several WASTE experts as well as SAWI clients and partners were consulted about their underlying motivation, assets as well as needs and expectations. The findings are summarised in Table 1.1 below.

	Supply side	**Demand side**
Motivation	Entering new markets, profit, social objective	Social objective
Assets	- specific technology or product - willingness to invest time and resources - rather pragmatic approach	- local knowledge and experience of developing sustainable and inclusive solutions in BoP projects - access to (local) finance, markets and networks - rather idealistic approach
Needs	- knowledge & experience on how to make business in the BoP - first orientation and a starting point - information about potential opportunities and partners - access to local markets and finance	- technologies and products that improve sanitation sustainably - R&D and production capacities - (financial) resources

Table 1.1 Motivation, assets and needs from supply and demand side

One can see that lack of knowledge and experience about introducing innovations to developing markets is the prevalent problem of the supply side. In order to successfully enter this new potential market, they need external support. The following quotes of SAWI clients illustrate this issue:

"*We think our technology could have a great potential in certain developing markets, but we have no idea about how and where to start."* Engineering Director, Thetford B.V.

"*We developed a great technology and are now looking for a partner who has the experience and knowledge to develop a business and set-up a value chain in developing markets. We are in contact with some local NGOs but this is time consuming and they are unable to think in business terms. We chose to work with you [SAWI] because with you guys we can also talk about numbers and business cases*." CEO, JAGRAN B.V.

"*We have a very promising technology for the use in developing countries but we are still at the beginning of internationalisation. Our experience is mainly limited to the Dutch market and some employees are not even used to speak English.*" Manager International Business, GMB

On the demand-side a combination of opportunities and externally-induced problems that eventually lead to the establishment of SAWI can be identified. During their work on projects to improve sanitation with their partners, WASTE experienced that there is a certain potential to improve the impact and the sustainability of these projects. On the one hand, projects could have had a better impact if innovative technology would have been available. On the other hand it posed to be challenging in the past to set up solutions that are really sustaining themselves after the end of a project. The typical project set-up relies on external funding such as from the Dutch government for

example and by the end of the project, financial and human resources are suddenly withdrawn. This is a great challenge for the continuity of a project. By involving the private sector and establishing a profitable business model, WASTE sees a potential to address this issue. A company would have a natural interest of sustaining and up-scaling a viable business model.

Besides these opportunities, WASTE is facing financial challenges that require alternative streams of income in order to sustain their activities in future. Main trigger of this development is a paradigm shift within the Dutch ministry for trade and development, currently WASTEs main source of funding (WASTE, 2012). Following a "from aid to trade" agenda, many funding schemes now require the involvement of the Dutch private sector with the aim to stimulate Dutch trade and economy as a result of the investment (Dutch Ministry of Foreign Affairs, 2013). SAWI was initiated in order build up experience in this field and to support WASTE regarding these challenges in two ways. Firstly, it can directly generate income for WASTE by providing paid services to the private sector. Secondly, it can initiate and develop projects that are eligible for the new funding schemes of the Dutch government.

One can see that supply as well as demand have various valuable assets and needs that complement each other in the way towards improving sanitation in a sustainable and profitable way. Both sides do however lack the knowledge and experience for a fruitful cooperation. The development of an initiative such as SAWI that translates between these two groups of stakeholders is clearly needed.

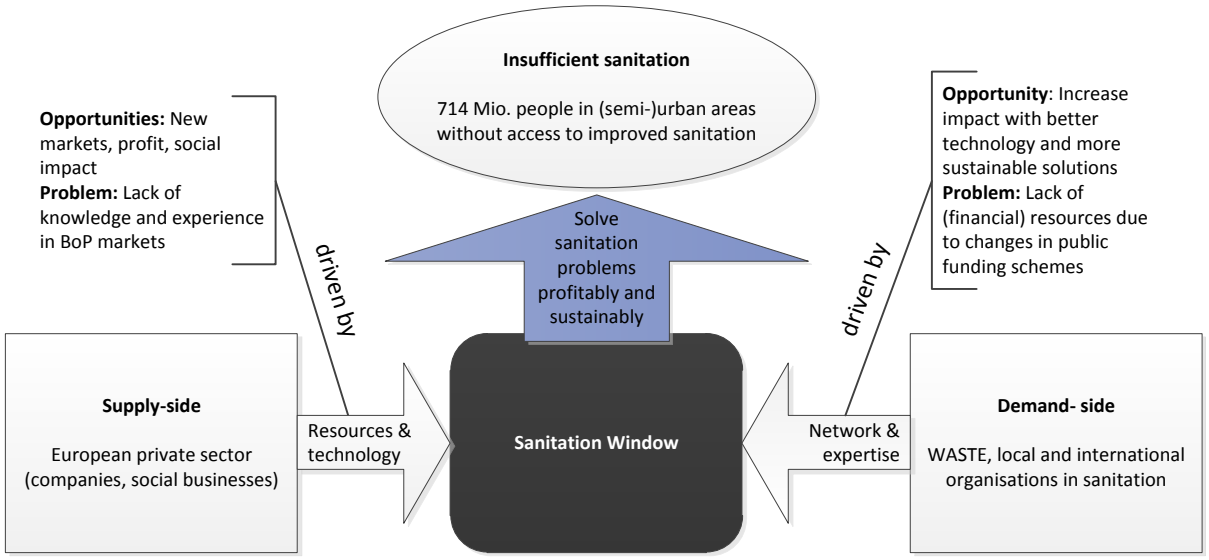

Figure 1.2 Overview of the study context

Figure 1.2 summarises this set-up. Sanitation Window acts as a facilitator between the supply and demand-side with the aim to translate the different assets and needs towards a sustainable and profitable sanitation solution.

2 Research assignment and methodology

In the previous chapter I elaborated the context of the study. I treated the study object "Sanitation Window" as a black box that aims to translate different assets and needs towards a sustainable and profitable sanitation solution. In this chapter, I will open this black box in order to specify the research objectives. By describing and critically assessing the SAWI way of working I try to identify its strengths and weaknesses that lead to the research questions. Finally, the methodology that is needed in order to fulfil these research objectives will be presented.

2.1 The SAWI way of working

During the R&D phase of SAWI, a way of working has been developed and documented. It provides a basic step-by-step guidance from the idea towards a sustainable implementation of a solution in a suitable emerging market. Each step concludes with a go/no-go decision, determining if the next step is taken or not. Additional to a general feasibility, this decision is also based on the fulfilment of the following SAWI guidelines (WASTE, 2013).

- The demand or supply can be placed within the sanitation chain
- The solution has to be safe for people and the environment
- The solution is financially sustainable on a local level
- The solution does not disturb and undermine the local private sector

SAWI distinguishes between a supply-oriented and a demand-oriented way of working as depicted in Figure 2.1. The demand-side is defined as "problem owners in emerging markets that have a demand for sanitation products or services that are currently locally not available" (WASTE, 2013). The supply-side is represented by European companies with innovative solutions for the sanitation chain in emerging markets.

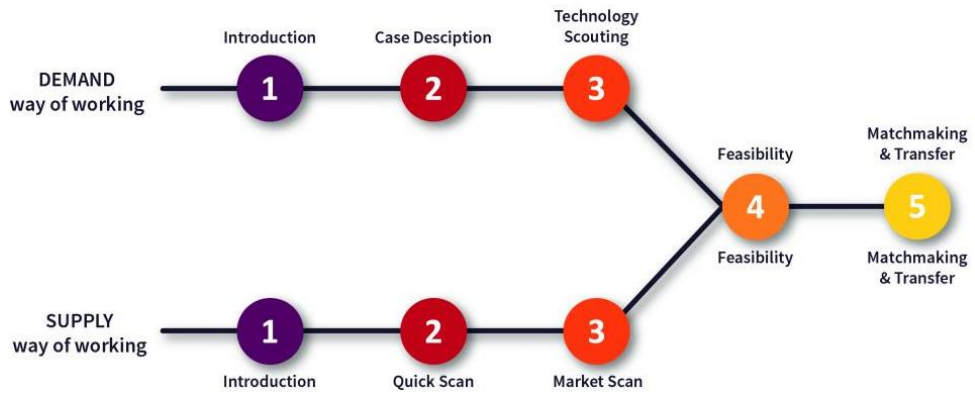

Figure 2.1 Diagram of "The SAWI way of working" (WASTE, 2013)

Both trajectories consist of five steps starting with an introduction. Goal of this first step is to identify if there is a potential for cooperation between the client and SAWI. During a first discussion, SAWI assesses if the demand or supply fits in the sanitation value chain and therefore within SAWIs scope of activities. Furthermore, SAWI tries to ensure to the extent possible at this stage, that the demand or supply complies with the SAWI guidelines.

The aim of the next step of the demand trajectory is to concretise the demand in such a way that a suitable solution can be identified in the following step. After checking the feasibility in step four, a strategy for the actual implementation of the identified solution will be developed and executed in the final step.

The introductory step of the supply trajectory is followed by a so-called Quick Scan. The goal of this step is to identify barriers, opportunities and requirements that are essential for the successful implementation of an idea. This step can be approached from two different perspectives that are referred to by SAWI as step 2a and step 2b. Step 2a takes an existing product as a starting point and identifies essential requirements that a market has to fulfil in order to be suitable. The outcome of step 2b is a set of essential product requirements that are needed to turn a promising technology into a suitable solution for certain market settings. Step three aims at a more thorough evaluation of previously identified product-market settings. Barriers and opportunities are identified by considering financial, institutional, environmental, technical and socio-cultural aspects. Based on the results of the previous step, (local) assessments will be then executed in order to validate the feasibility in the fourth step. Finally, a strategy for the implementation will be developed and executed.

2.2 Research assignment

Within the last two years SAWI already executed several of the above-described steps in collaboration with various stakeholders. The research assignment results from an orientation phase reviewing these past activities. By interviewing the SAWI team members, other WASTE experts and reviewing the documentation of existing work I gained insight into the way of working and was able to identify some opportunities for development that lead to the research questions and research objectives.

2.2.1 Problem analysis

Innovation processes are usually associated with a high degree of uncertainty and actual courses of technological development are difficult to predict (Markard, et al., 2009). Despite this, SAWIs task is to identify opportunities and guide sustainable innovations in the best possible way. This strongly depends on the ability to understand an innovation setting and come up with a suitable strategy. An analysis of the past activities of SAWI below reveals, that this can be quite challenging.

Starting point of past SAWI activities was the research and identification of potential supplies (e.g. products) and potential demand settings (e.g. countries, cities, projects). Major focus of the activities was the investigation of potential supplies. About 30 companies with promising products and technologies have been identified through existing contacts and desk research. About half of them have been contacted and most companies showed initial interest about the possibility to serve markets in developing countries with their product or technology. Three of these companies have been selected for further investigation at cost of SAWI in order to build up expertise and to create a portfolio of show cases. Furthermore, one company approached and assigned SAWI to conduct an investigation for their technology and products in developing markets.

The SAWI five step approach guided these investigations in a very general way by defining what to do (e.g. “Introduction” followed by a “Quick Scan”). It gives however just little guidance about *how* to conduct these steps and especially how to link the different steps to each other. So far, the WASTE analysts conducted these steps mainly in an ad hoc manner. Already an initial analysis (“Quick Scan”) results however in a huge variety of information which makes it challenging to extract specific recommendations for the next steps. WASTE analysts described that they mostly rely on a “gut feeling” to come up with recommendations. This requires not only a high degree of expertise and experience, but it also bears a high risk of making poor, biased choices. Furthermore, this proceeding makes it difficult to explain and justify recommendations towards clients and other stakeholders.

Recent examples confirm that the current way of working has its limitations. SAWI conducted a quick scan for a company that yielded very promising results in terms of feasibility and market potential. SAWI was however not able to translate these opportunities into a convincing strategy. Neither the

company nor SAWI are sure about if and how to continue the partnership. In another case, SAWI identified a good match between a Dutch technology and the needs of an African sanitation company. SAWI was however struggling to come up with a strategy to further pursue this opportunity and to define its own position in such a strategy. Finally, this way of working in general is very dependent on the individual WASTE analyst. Ad hoc approaches and decisions based on a "gut feeling" (that reflects the experience and expertise of an individual analyst) are difficult to document and comprehend by others. Personnel changes are therefore a considerable threat to the continuity of a project as WASTE already experienced in the past. To conclude, we can see that WASTE needs a more structured and transparent approach to improve its ability to guiding sustainability oriented innovations in sanitation.

In the past 15 years, various concepts emerged from sustainability oriented innovation and technology studies addressing such innovation challenges. Key contributions of this field are the concepts of Transition management (TM), Strategic niche management (SNM), the Multi-level perspective (MLP) and Technological innovation systems (TIS) (Markard, et al., 2012). By taking a systems perspective, these concepts aim to cope better with the high complexity of innovation processes that are often characterised by a high degree of uncertainty, non-linearities and co-dynamics (Markard, et al., 2009). Although these concepts are a promising starting point to address above-identified problems, it is often difficult to extract practical guidelines from studies of this kind (Bergek, et al., 2008). The functions approach to innovation systems (FIS) based on the TIS concept is the first approach designed for overcoming this issue and providing a practical scheme of analysis aimed at extracting practical guidelines. Using the concept of TIS as a basis, the FIS has the potential to deal more explicitly with firm strategies and agency compared to related approaches (Markard & Truffer, 2008; 2008a). This focus is essential for its use in an organisation such as WASTE. For this reason, the TIS concept along with the FIS is given preference as a theoretical foundation in this research instead of other concepts for which no comparable practical schemes of analysis exist yet.

Even though the FIS seems to be a promising concept and good theoretical foundation, its application in an organisation such as WASTE and in the area of sanitation in development has not been adequately explored and addressed in literature yet. This research aims at closing this gap between the current FIS concept and its use in the WASTE context. This leads to the following research question:

How can the functions approach to innovation systems contribute to a sustainable introduction of innovations into sanitation chain settings of the global South?

- *How to capture the structure and dynamics of a sanitation chain setting?*
- *How to identify barriers and opportunities for an innovation in a sanitation chain setting?*
- *How to derive efficient policy recommendations and strategies for the stakeholders?*
- *What are, based on this research, the implications for the future development of the functions approach to innovation systems?*

2.2.2 Research objectives

This research intends to contribute to a solution for the above identified problems. Based on the previous analysis and the research questions, the research objectives can be formulated as follows:

1. Analysing the challenges of WASTE and explore the use of the FIS as a possible solution to capture the structure and dynamics of sanitation chain settings, identify barriers and opportunities and come up with efficient policy recommendations and strategies.

2. Designing a customised FIS manual for WASTE that supports the assessment of sanitation chain settings based on the findings of the analysis.
3. Reflecting on the findings and giving recommendations for further research.

It can be seen that these research objectives have practical as well as scientific relevance. The practical relevance is given due to the fact that this research aims at solving practical challenges of WASTE and its clients. Gaining knowledge about the application of the FIS in this specific context also aims to contribute to science in the field of transition literature. Identified deficiencies in literature and further refinement of the FIS may be also relevant to other contexts.

2.3 Methodology

In the previous section the research questions and objectives were derived, giving this research a central guidance and orientation. This section gives an overview of how I will deal with these research questions from a methodological point-of-view.

This research aims to tackle an organisational challenge in a real-life organisation. An analysis with the help of research methods from social science research can be therefore just one part on the way towards a solution. In order to cover the research objectives comprehensively, a design-oriented theory-informed approach is chosen. This methodology goes beyond an analysis only and also aims at the design of a sound solution and the actual realisation of performance improvement with the help of this design (van Aken, et al., 2012). Theory-informed means that this problem solving process is not carried out in a craftsman-like way as it is common practise in organisations, but by the "comprehensive, critical and creative use of theory" (van Aken, et al., 2012, p. 7).

The research will be conducted following the concept of reflective redesign as shown in Figure 2.2. Starting point is a business phenomenon for which the solutions are not yet adequately addressed in academic literature. This part is covered by the orientation phase and resulted in the research assignment presented in the previous section.

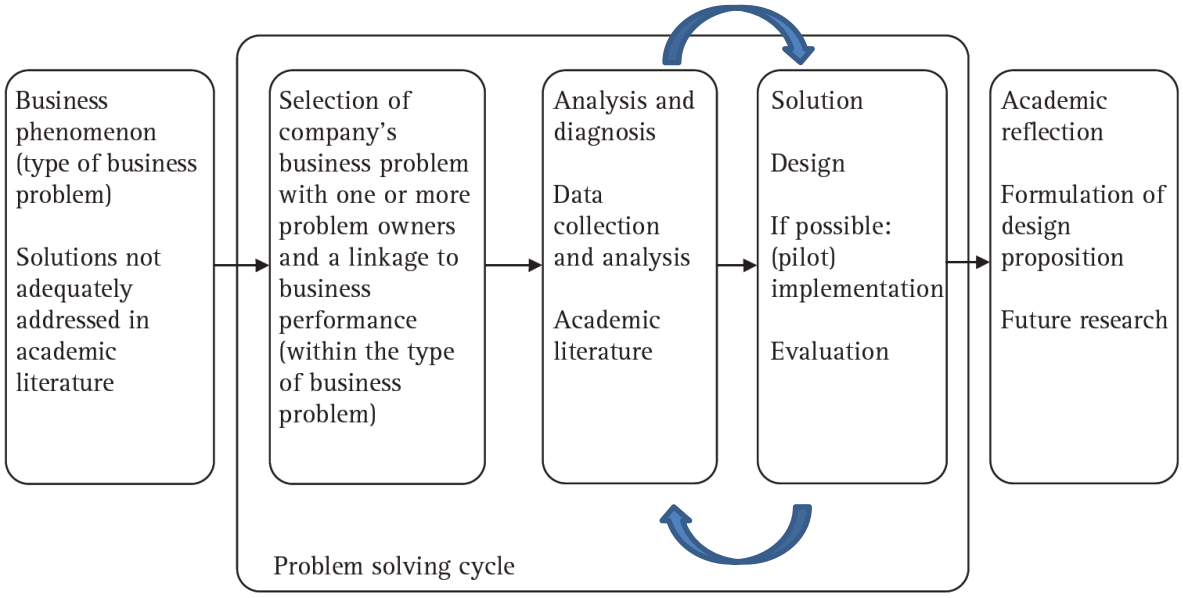

Figure 2.2 Concept of the reflective redesign (van Aken, et al., 2012, p. 18)

After introducing the academic literature in more detail the problem solving cycle is entered by selecting two specific SAWI cases for which an analysis and a specific solution design will be carried out. The specific solution design is an iterative process that involves a continuous evaluation and redefinition of the problem definition and the design. The final step moves away from the specific cases towards a more aggregate level. By reflecting on the design process, more generic guidelines are derived resulting in a general design proposition that allows WASTE to tackle challenges in other projects on a similar way. A reflection on the role of the academic literature in this design process may lead to more generic contributions to the FIS and point to opportunities for further research. Figure 2.3 gives a systematic overview of the components that lead towards the fulfilment of the research objectives.

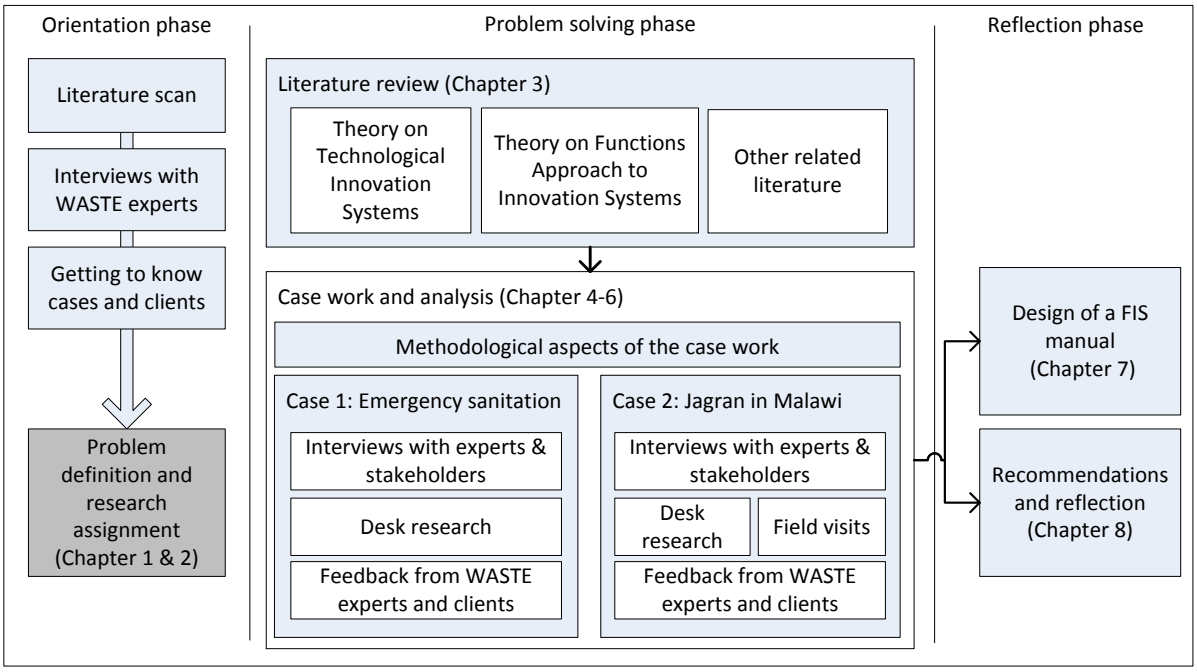

Figure 2.3 Research process based on the reflective redesign concept

The orientation phase has two objectives. Firstly, it aims at getting an understanding of the organisation WASTE, its way of working and the underlying problems, leading to the problem definition. This is achieved by desk research using internal WASTE documents and discussions with WASTE employees. The problem has to be not only relevant to WASTE but also framed in a way that it is relevant to the innovation studies discipline. Secondly, in order to solve the identified problem, the research design has to be developed and practical arrangements have to be made. A literature scan in the field of innovation studies is conducted in order to identify concepts that serve as theoretical foundation of the research. Furthermore, I got accustomed with the current clients and projects and selected the ones that are most suitable for the research. The results of this phase are presented in this and the previous chapter.

The literature review follows up on the literature scan in the orientation phase. It aims at giving a comprehensive overview of literature related to the FIS. As there is still a manageable amount of FIS literature, it is aimed to review most of the available and accessible journal articles, working papers etc. related to the development and application of the FIS. For a compact presentation, findings are consolidated and examples are used to highlight interesting aspects. For further insight into the underlying concepts of the FIS, key contributions related to TIS and the functions concept are

presented. These are identified by following up respective references in FIS literature. Other related literature is presented where applicable.

In order to gain in-depth insight about the applicability of a practical-oriented approach I decided to explore its use in the real-life context. This helps to gain knowledge during the information gathering and analysis process and gives the opportunity to explore ways to present the analysis and its results. Besides, WASTE and its clients may be directly able to benefit from the outcomes of such an analysis of a real-life project. Furthermore, the resulting case descriptions can complement the manual by serving as a reference and example for future analyses. The scope and time-frame of this research allowed the selection of two cases based on current SAWI activities: Emergency Sanitation and the JAGRAN Musca Domestica technology. Following the reflective redesign, these two cases allow me to perform two iterations of the problem solving and design cycle towards a final design proposition. The choice of these two cases was influenced by several factors. Most importantly, it is aimed to explore the applicability of the FIS approach for a wider spectrum of WASTE activities. This would be not possible with just one case or several, very similar cases. Emergency Sanitation is representing a relatively wide knowledge field that is quite related to the SAWI demand way of working. In contrast, the second case is narrowly focused on one location and technology, representing a typical supply case (cp. Section 2.1). Hence, both cases together represent a good range of typical WASTE innovation projects of which many similar ones are expected to be conducted in future. Naturally, also practical considerations such as time-frame, scope and budget had an influence on the case selection. The exploration of these cases can be divided into two phases that are conducted in an iterative way: information gathering and the analysis. Determining suitable methodologies for these phases is part of the exploration process itself. Existing approaches, suggestions and methodologies that are identified during the literature review serve as a starting point. For reasons of clarity and to be able to use the case descriptions as example FIS analyses, I decided to separate the methodological deliberations and findings from the analysis itself. These are described in Chapter 4 and Chapter 7 along with the design choices that are derived from it.

Finally, by taking a step back and reflecting on the overall research, I will give recommendations for further research activities. I will try to determine to what extent the design contributes to the identified problem and which aspects still have to be addressed. Furthermore, I will reflect on the research design that is presented here in order to determine if it is sensible to be used for future research or if adjustments have to be made. Finally, based on the literature review and the case work, I will point out opportunities for further development of the underlying theories.

3 Literature review

In this section, the scientific literature that will be used as foundation for the theory-informed problem solving approach will be reviewed and put into the context of this research. Besides giving an overview of the concepts of Technological Innovation Systems (TIS) and the Functions Approach to Innovation Systems (FIS), first methodological aspects are discussed and gaps in literature are pointed out.

When conducting a development project it is extremely important to have a good understanding of how the context influences the project and vice-versa. This belief is deeply embedded in WASTEs and SAWIs way of working and has been also pointed out in literature. As a result of observing numerous development projects, Hirschmann (1967) makes thereby a useful distinction between "trait-takers" and "trait-makers". Trait-taking projects are adjusted to fit a given environment and accept its traits. In contrast, trait-makers are designed in a way that aims at actively changing traits of the environment in order to make the project a success. Hirschmann further notices that: "Bringing, as they do, new activities in a pre-existing environment, development projects are likely to imply far more would-be trait making than is commonly realised and a principal task of the project analysis is to uncover the most significant economic and socio-political changes on which the success of the project is implicitly premised" (Hirschmann, 1967, p. 145). This indeed well describes one of the important tasks of WASTE. By analysing and uncovering important developments in the project context, WASTE can not only gain insight about the potential of a certain project and how to make it fit into an environment but also guide it in such a way that it may be, despite of its limited resources and size, able to challenge and actively change traits on its way towards a successful and sustainable large-scale diffusion.

The FIS is chosen as a theoretical foundation because it offers to be a tool to conduct such analysis and identify means to speed up the diffusion of a technology (Bergek, et al., 2008; 2008a) . In line with Hirschmann's concept of "trait-makers" it is based on the premise that not only policy makers but also entrepreneurial actors have an active role in the formation of a supporting system and should pay attention to system-building activities from an early phase (Bergek, et al., 2008a). Using the concept of TIS as a basis the FIS has the potential to deal more explicitly with firm strategies and agency compared to related approaches (Markard & Truffer, 2008; 2008a). Bergek et al. (2008a, p. 92) nicely characterise the advantages of the functions approach in this context:

> *"Through the separation of structure from key processes at the functional level, the functions approach provides a systematic method of mapping determinants of TIS dynamics and to identify the need for system building activities. It, thus, enhances the analytical power of the IS approach. This is particularly important from the perspective of an entrepreneurial firm, which cannot influence all functions simultaneously but instead needs to decide what functions to influence and what organisations to link up to in order to influence other functions (Van de Ven, 1993)."*

It is important to mention at this point that also other notions can be found in transition literature. Some scholars argue that a suitable environment is a *precondition* that should be fulfilled before a TIS is stimulated. As an example, Painuly (2001) analyses barriers of renewable energy technologies and concludes that large-scale policy, top-down intervention (e.g. by governments) is required *before* any further development can take place. In contrast, the innovation/innovator itself is put in a quite static, passive role (Painuly, 2001). Especially in the context of this research, this view can be problematic. Large-scale policy intervention requires an appropriate policy maker, e.g. a government that is already

convinced of a certain transition path and willing as well as capable to intervene. This is however often not the case as these actors may be conservative and hesitant towards innovations, following a different agenda, showing a great deal of inertia or simply be non-existent. Painuly does not offer a solution to this dilemma that is in fact very prevalent in the area of development. In contrast, actors such as WASTE are trying to actively target such settings without waiting for large-scale policy intervention to happen but to immediately take meaningful action within their area of influence (which may lead to policy intervention after all).

3.1 Technological Innovation Systems

Fundament of the FIS as proposed by Bergek et al. (2008) is the concept of Technological Innovation Systems (TIS) that has been introduced by Carlsson & Stankiewicz (1991) and is briefly described in this section.

The concept of TIS describes how different actors, networks and institutions form a system around a technology (Carlsson & Stankiewicz, 1991). It is based on the commonly accepted premise that technological change is a main determinant of economic growth. In contrast to neoclassical models that treat technological change as an exogenous factor, the TIS concept aims for a more endogenous integration. Carlsson & Stankiewicz define a technological system "as a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilisation of technology" (Carlsson & Stankiewicz, 1991, p. 93). The TIS concept takes a systems view on technological change where firms or innovations are not taken individually but are part of a larger system where various agents interact with each other and institutions matter (Carlsson & Stankiewicz, 1991). Its three components actors, networks and institutions can be characterised as follows:

Besides firms, the *actors* include other organisations such as NGOs, universities or government bodies along the value system of a TIS. These organisations provide the system with knowledge or capital for example. There are different kinds of *networks* that are formed by several actors. *Learning networks* between firms, users and universities for example allow the transfer and development of knowledge and enable the articulation of expectations and visions (Geels & Raven, 2006). *Political networks* are made up of actors sharing a set of beliefs seeking to influence aspects of the political agenda. The element *institutions* describes aspects that regulate the interaction between actors, i.e. laws, norms and rules (Carlsson & Stankiewicz, 1991). Based on these elements, three structural processes are involved in the formation of a new TIS: entry of actors (firms and other organisations), formation of networks and institutional alignment (Bergek, et al., 2008a).

According to Carlsson & Stankiewicz (1991) this system as its whole ultimately leads to economic change once all elements are in place, following the school of evolutionary economics. Its three mechanisms are illustrated in Table 3.1.

Variety and relationship between variety and innovation	Creation of variety ("new combinations") and its successive reduction through selection in a socio-cultural environment
Innovation	Search for, discovery, experimentation, development, imitation and adoption of new technology (products, processes) in an interactive process sometimes involving both users and producers and heavily influenced by the organisational and institutional structures around it
Diffusion	Reaching substantial market penetration influenced by technical, organisational and institutional interrelatedness (path dependency)

Table 3.1 Sources of economic change (Carlsson & Stankiewicz, 1991)

One can see that all three of these mechanisms are heavily influenced by its context, represented by organisational and institutional factors. Carlsson & Stankiewicz point out the most important factors leading towards the concept of "Technological Systems" as shown in Table 3.2.

narrow view

Economic competence	Sum of a firm's abilities to take advantage of business opportunities
Clustering of resources	The need for interaction among agents with different competence requires some form of (e.g. geographical or technological) clustering of resources
Networks	Intermediate form of organisation between hierarchies and markets with (often informal) exchange of information as essential function.
Development blocks	Along with a favourable environment, entrepreneurs provide the spark or the vision that turns a network into a development block, i.e. a network with a dynamic force along a technological trajectory
Institutional infrastructure	Set of institutional arrangements (both regimes and organisations) which, directly or indirectly support, stimulate and regulate the process of innovation and diffusion of technology
Technological systems	Network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology

broad view

Table 3.2 Organisational and institutional factors (Carlsson & Stankiewicz, 1991)

Carlsson & Stankiewicz acknowledge that the TIS concept is just a starting point opening up a whole new set of questions. Properly defining boundaries and determining the importance of different actors and institutional aspects are important issues to be resolved when conducting an analysis based on the TIS concept.

3.2 Functions approach to innovation systems

With the functions approach to innovation systems (FIS) Bergek et al. (2008) provide a scheme of analysis that aims at extracting practical guidelines based on studies of innovation systems. The focus lies thereby on the previously introduced concept of TIS which is primarily used as an analytical construct (Bergek, et al., 2008).

Additionally to the structural composition of a TIS, the FIS aims at also capturing its functional dynamics. For this, the FIS relies on a set of several important functions that have been identified in literature as contributing to the development and diffusion of an innovation. Although the number of functions, their naming and definitions slightly differ between authors, a relatively broad agreement seems to exist about the most important functions (Johnson, 2001). I will use the set of functions from Hekkert et al. (2007) which is slightly different from the one used in the initial FIS concept by Bergek et al. (2008). It is verified by extensive empirical research (Hekkert & Negro, 2009) and was often used in recent literature (Schmidt & Dabur, 2013; Tigabu, et al., 2013; Meelen & Farla, 2013). Table 3.3 provides a brief description of these functions.

#	Function name	Description of the system function
F1	Entrepreneurial activities	At the core of any innovation system are the entrepreneurs. These risk takers perform the innovative commercial experiments, seeing and exploiting business opportunities.
F2	Knowledge Development	Technology research and development (R&D) are prerequisites for innovation. R&D activities are often performed by researchers, but contributions from other actors are also possible.
F3	Knowledge diffusion	The typical organisational structure of an emergent innovation system is the knowledge network, primarily facilitating information exchange.
F4	Guidance of the search	This system function represents the selection process that is necessary to facilitate a convergence in development, involving, for example, policy targets, outcomes of technical or economic studies and expectations about technological options.
F5	Market formation	New technologies often cannot outperform established ones. In order to stimulate innovation it is necessary to facilitate the creation of (niche) markets, where new technologies have a possibility to grow.
F6	Resource mobilisation	Financial, material and human factors are necessary inputs for all innovation system developments, and can be enacted through, e.g., investments by venture capitalists or governmental support programmes.
F7	Creation of legitimacy / counteract resistance to change	The emergence of a new technology often leads to resistance from established actors. In order for an innovation system to develop, actors need to raise a political lobby that counteracts this inertia, and supports the new technology.

Table 3.3 Functions of innovation systems from Hekkert et al. (2007)

Based on the TIS concept and these seven functions, the functions approach to innovation systems (FIS) describes a six step approach that needs to be carried out by the analyst (Bergek, et al., 2008). It is important to notice that the approach, although it seems to be laid out in a linear fashion, allows iterations between the steps as it might be required in many cases.

After setting the boundaries and defining the TIS in question in the first step, the structural components of the TIS (actors, networks and institutions) are identified in the second step. The third step aims at describing the current state of the TIS with the help of the seven functions. In the following step the performance of the functional pattern is assessed. Furthermore, goals how a desirable functional pattern should look like are defined in this step. Step five analyses the

mechanisms that drive or block a development towards the desirable functional pattern that were defined in step four. Finally, this leads to the identification of key policy issues in step six, that help to enforce inducement mechanisms and remove blocking mechanisms so that the desired functional pattern can develop. Figure 3.1 illustrates the six steps that are described in more detail in the following section.

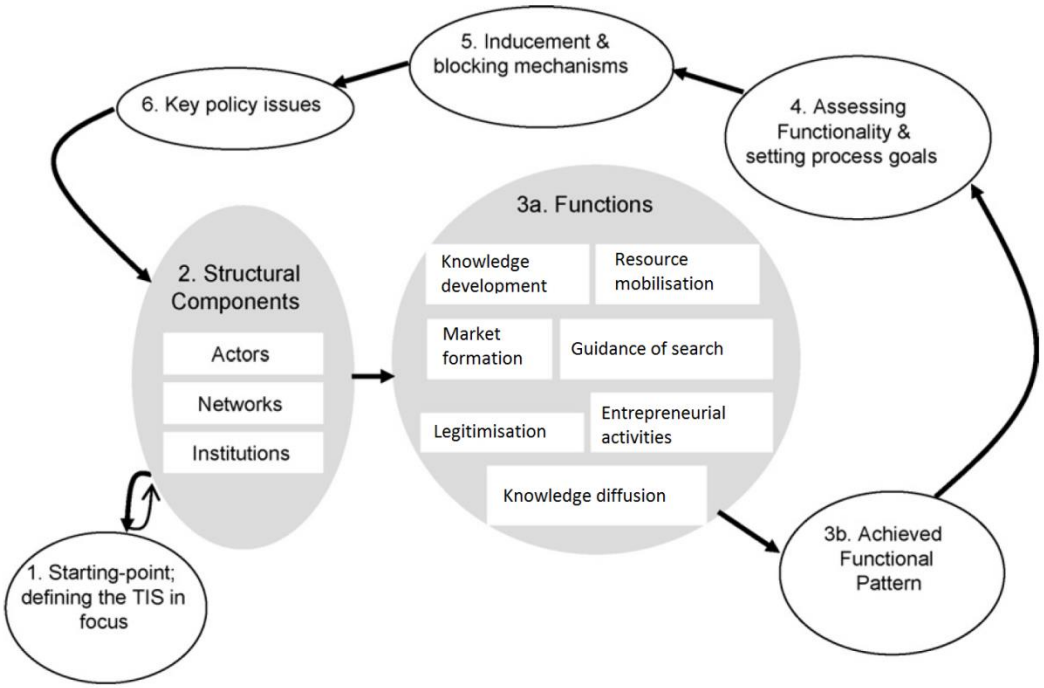

Figure 3.1 The scheme of analysis (adapted from Bergek et al. 2007)

3.3 The FIS scheme of analysis in detail

In this section the FIS will be elaborated in more detail in order to serve as a starting point for the case work. I will present and review existing approaches found in literature with their application in the context of WASTE in mind. An important task hereby is to put the FIS in context of guiding sustainable innovations in the sanitation chain as there is currently a strong bias in literature towards applying the FIS in the area of renewable energy technology, mostly in developed countries. Furthermore, much of the current literature focuses on policy makers and academic researchers as a target group. As Bergek et al. (2008a, p. 108) state, the FIS "has already proven its usefulness with respect to policy but it is untried as yet from an entrepreneurial perspective, although the work of van de Ven (1993) on very similar lines suggests that it is so."

3.3.1 Determining the desirability of the technology in focus

As Bergek et al. (2008a, p. 108) point out "the framework has nothing to say about the desirability of a particular technology" and in most of the cases in FIS literature this is indeed simply taken for granted and not further discussed. In the context of WASTE it is however essential to continuously assess the desirability of the knowledge field or technology in question before the decision is taken to support its further development. It is an integral part of the SAWI way of working and should be therefore considered in an overall approach. The SAWI guidelines (see Section 2.1) and WASTEs FIETS sustainability principles (see Table 3.4) provide guidance for this and may be a useful addition to the existing six steps.

Financial sustainability	Minimise dependency on external subsidies, using the principle "local finance first" aimed at strengthening the "in-country" structural finance.
Institutional sustainability	Ensure systems, institutions, policies and procedures at the local and national level are functional to meet the (long-term) demand of users of water and sanitation services.
Environmental sustainability	The impact of the project on the environment (in particular for water and soil) and the living conditions of the target group should not be harmful.
Technological sustainability	Technologies applied should be of high quality, and need to suit the local context, affordable and durable.
Social sustainability	Making interventions demand-driven, inclusive and needs-based, being sensitive to local and cultural incentives, addressing issues of exclusion and focusing specifically on women as change agents.

Table 3.4 FIETS sustainability principles (WASTE, 2013)

3.3.2 Step 1: defining the TIS in focus

Starting point of an analysis is a definition of the TIS in focus. Spending some thought on setting the right scope is essential in order to conduct an efficient analysis that fulfils the needs and expectations of all relevant stakeholders. It is important to be aware of the influence of the TIS definition on the final result and communicate it to and align it with all relevant stakeholders accordingly. This is not necessarily a linear process given the large uncertainties involved. Initial assumptions may prove wrong and might require going one step back and re-defining the initial TIS at a later point. Practical considerations may play an important role for the definition of the TIS. Insufficient resources to conduct a comprehensive analysis might lead to a quite arbitrarily narrowed down TIS definition for example.

According to Bergek et al. (2008), technology incorporates (at least) two interrelated meanings: it can refer to a product/artefact as well as to a knowledge field. In case a firm would like to explore the potential of an existing product, the product perspective is a good starting point for analysis. If a firm would like to explore the potential of developing a new product or SAWI is interested in exploring the opportunities for several competing or still-to-be-found products in a certain field for example, the broader definition of a knowledge field is a suitable focusing device. Secondly, Bergek et al. (2008) propose "level of aggregation" and "range of applications" as determinants to further specify a TIS. Depending on the requirements of the analysis, the *level of aggregation* may be quite narrow and specific (e.g. light-weight urine diversion pit slabs) or rather broad (e.g. raised latrines). The *range of applications* can be defined in terms of a certain market segment (e.g. emergency sanitation) and/or a certain location (e.g. urban areas in Kenya).

3.3.3 Step 2: identifying the structural components

In the second step the structural components of the TIS, that are the actors, networks and institutions, are identified. This provides a basis for the functional analysis of the TIS in the following step. Related literature describes various approaches of identifying structural components that are discussed in this section.

In case a TIS is already existing and built around specific industries, numerous sources such as historical data, industry directories, patent analyses or bibliometric analyses for example are available to identify the relevant *actors*. Most of this data is however difficult to acquire for TIS that do not yet exist, that are just emerging or that are not built around a specific, well-documented industry (Bergek, et al., 2008).

This is typically the case for analyses that take place in a development setting where one has to cope with a diverse set of local and global actors. In such cases, Bergek et al. (2008) suggest to conduct interviews and discussions with known experts ("gurus"), firms, research organisations, financiers etc. Additional actors can be then identified using a snowballing method where each questioned actor points out other relevant actors in the field. Also formal and especially informal *networks* can be identified on this way. This method was successfully applied in several cases dealing with emerging TIS and including a couple of cases in the development context (Rickne, 2001; Schmidt & Dabur, 2013; Tigabu, et al., 2013). As WASTE has access to a large network of experts in the area of interest this method may be very suitable in this context. Additional to this, especially in the context of emerging TIS, it may be needed "to look for subtle signs pointing to the existence or non-existence of networks" (Bergek, et al., 2008, p. 413). Based on certain events it may be possible to *deduct* if there is a well-functioning network or a lack of it. Capturing the *institutional* aspects of a TIS requires a very wide lens of analysis as they come in great variety and influence a TIS in many different ways. Besides aspects directly tied to the TIS in focus such as culture, norms, laws, regulations and routines it may be also needed to include more general developments that could be characterised as "a set of deep structural trends" following the concept of technological landscapes (Geels, 2002). Also deducting the lack of institutions may be an important aspect of an analysis.

There are several ways to consider the identified actors, networks and institutions in an analysis. Whereas some authors largely focus on the functional aspects of a TIS (Rickne, 2001; Jacobsson & Bergek, 2004; Jacobsson, et al., 2002) others deal more explicitly with individual actors and how they are positioned within and around the TIS. A *technology chain analysis* allows positioning actors regarding their area of expertise such as production, distribution, storage, conversion and use for example (Suurs, et al., 2009; Oltander & Vico, 2005). The WASTE *sanitation chain* (see Figure 3.2) is quite similar to the above-mentioned technology chain analysis. As individual actors do usually not cover all parts of the sanitation chain, this way of structuring may be useful to identify dependencies between different actors and assess the overall completeness of a sanitation chain setting.

Figure 3.2 The sanitation chain (WASTE, 2013)

Van Alphen et al. (2008) and Alkemade et al. (2007) are mapping the actors using the classical *modules in the Innovation System* i.e. supply of technological knowledge, demand of technological knowledge, bridging infrastructure between supply and demand and supportive infrastructure as a starting point. Well served functions then ensure that these modules perform well. For illustration, Figure 3.3 shows how to group actors in a TIS based on a quite general variation of the concept of modules in the innovation system. Besides supply and demand it includes three actor groups that are not directly part of a sanitation chain: research & education, support organisations and institutions. Other variations of this concept also include a group of intermediary organisations that act as a broker between supply and demand (cp. van Alphen, et al., 2008). Markard & Truffer (2008) introduce the *multi-level perspective* (MLP) as a complementary concept to position elements within and around the TIS in niches, regimes and the already previously mentioned landscapes. Schmidt & Dabur (2013) distinguish between local actors, networks and institutions in a "national TIS" and global ones in an "international TIS".

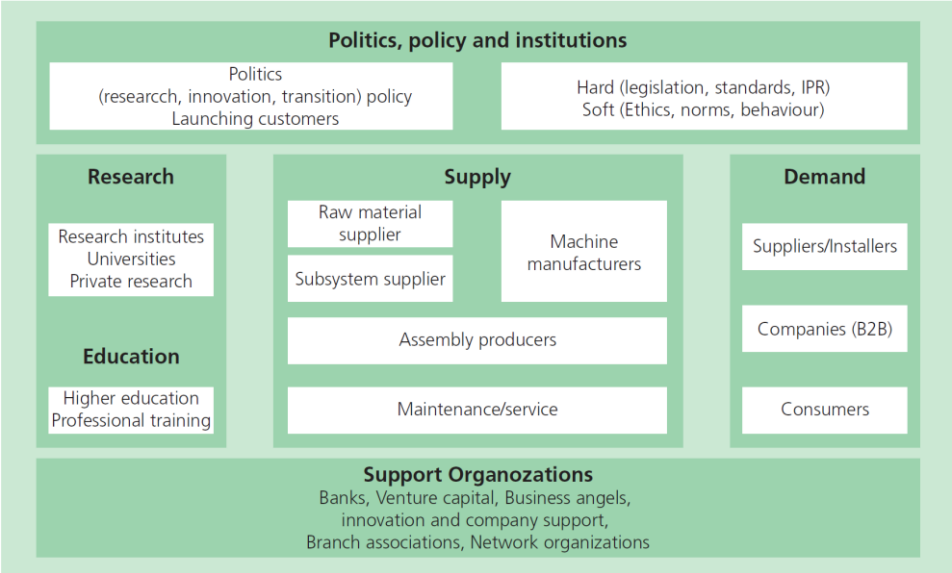

Figure 3.3 Variation of the modules in the innovation system concept (Hekkert, et al., 2011)

There are also more specialised concepts that may be helpful to group the actors of a TIS. With the so-called Diamond (see Figure 3.4) WASTE is offering such a specialised concept for sanitation settings in developing countries. It was developed based on past experiences in sanitation projects and puts a focus on local implementation. Actors such as e.g. international organisations are therefore not given the role of intermediaries but deliberately positioned as external contributors that can and should retreat once the Diamond is set-up.

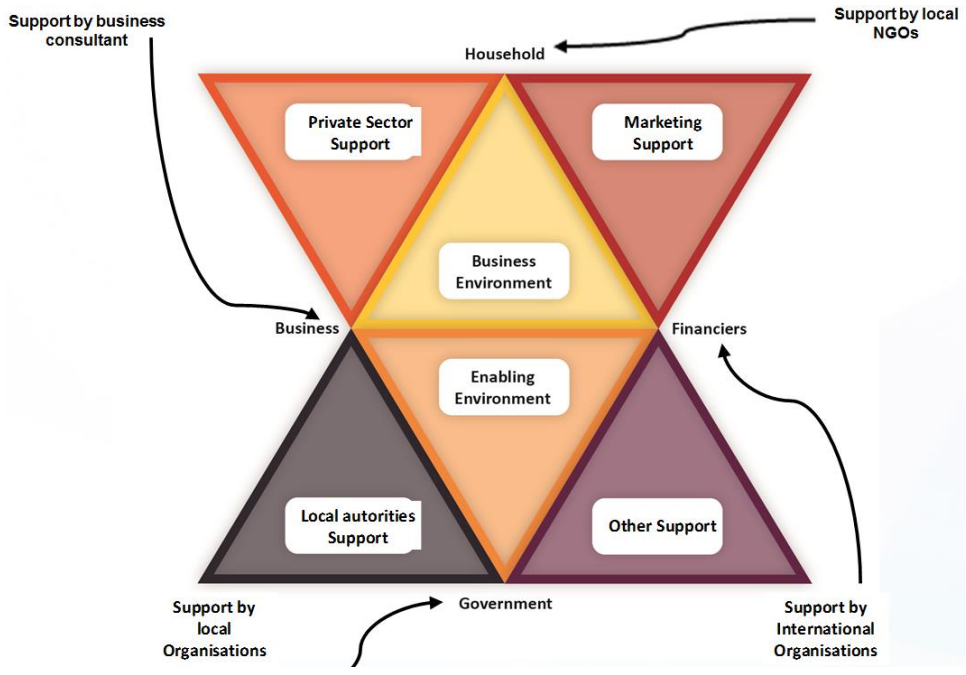

Figure 3.4 The WASTE Diamond (WASTE, 2014)

The role of the stakeholders is not only limited to their position in the TIS. It is the actors that actually generate, diffuse and utilise technologies and the build-up of a TIS depends on their presence, skills and willingness to take action (Suurs, 2009). Suurs et al. (2009; 2010) therefore introduce the socio-

cognitive *enactors-selectors perspective*. Analysing this aspect may help to elaborate on the different strategic options within a TIS and help to explain why certain actors may perform (or not perform) certain actions in a certain sequence. It is based on the principle that, depending on their relative position in a TIS, actors will frame their world differently and act accordingly (Suurs, 2009). Table 3.5 illustrates typical characteristics of enactors and selectors.

Enactors	**Selectors**
Actively involved from the beginning	Wait for enactors to take the first step
Stick to specific technological solutions	Take into account a broad set of technological options
Experience-based approach to knowledge development	'Objective' approach to knowledge development
Emphasise benefits and de-emphasising costs	Employing broad evaluation frames
Small technology developers	Regulators, financers, large firms

Table 3.5 Typical characteristics of enactors and selectors (Suurs, 2009)

Identifying and supporting a certain enactor in the right way could for example influence a large number of selectors towards supporting a certain innovation. The roles of the actors may also change over the time and enactors may become selectors and vice-versa. A selector could for example become an enactor over the time due to guidance or incentives to focus on a certain technology and take the first step to develop it further. It is important to notice that these characteristics of enactors and selectors are very technology-focused. Sanitation related cases may require a much broader perspective as technology is just one part of a comprehensive sanitation solution. Experiences in past WASTE sanitation projects show that enactors can for example also be found in the finance sector (e.g. micro finance institutes) or the demand side (e.g. a government expressing demand for local fertiliser sourcing), putting technology providers in a selector role.

The examples above illustrate that there are various concepts to analyse and group stakeholders in a TIS that may be used, adapted or combined for a FIS analysis in the WASTE context. This choice can be crucial as some elements (e.g. intermediary organisations) may already carry inherent assumptions about how a TIS should develop and therefore pre-define the range of strategic options. This has to be further explored in the following chapters. By trying out the different concepts in the two cases I may gain more insights about what are suitable ways to group the stakeholders of a given TIS in this context.

3.3.4 Step 3: mapping the functional pattern of the TIS

In this step, the functional pattern of the TIS is described based on the seven functions that were introduced in section 3.2. It gives us a picture of what is currently going on in the TIS but does not yet have any normative features assessing the "goodness" of the identified functional pattern (Bergek, et al., 2008). Secondary data such as reports, websites, catalogues, periodicals or professional journals for example can give an overview, whereas detailed insights are gained primarily by means of interviews (Bergek, et al., 2008a). Hekkert et al. (2007) propose a set of indicators related to the functions that are supposed to provide guidance during interviews and desk research. For the purpose of illustration, Table 3.6 shows such a set of indicators that I developed based on the function descriptions and with the WASTE context in mind. The aim of such a table is not to present a complete list covering all possible indicators but to provide guidance during the research process and during the information gathering phase (e.g. interviews) in particular. It has to be explored in the next chapters if such indicators are indeed useful. New insights that emerge during the course of the research may lead to an adjustment and refinement of these indicators or indicate that the use of an entirely different approach is more suitable.

#	Function	Development indicators
F1	Entrepreneurial activities	Firms introducing strategies regarding new business development Actors searching for new business opportunities and how to exploit them Actors conducting commercial experiments with new combinations of knowledge, applications and markets Actors searching for possible applications of novel technologies Efforts towards a large-scale production
F2	Knowledge Development	Investments in research/performing research Conducting feasibility studies/market assessments/pilots Developing new designs/prototypes Adapting or modifying existing models Developing complementary technologies Perceived degree of mismatch between (academic) research and demand by firms
F3	Knowledge diffusion	Trainings of entrepreneurs, technicians etc. Awareness campaigns Workshops, conferences, seminars, meetings etc. Promoting show cases / results of demonstration projects Perceived homogeneity/heterogeneity of actor-networks
F4	Guidance of the search	Alignment of relevant subsidies, regulations and policies Identified or perceived needs / market gaps / clarity about demand Changing business context (e.g. saturated markets, economic crisis) Technology and business trends Success stories / trigger events (e.g. natural disasters) Visions and expectations / belief in growth potential
F5	Market formation	Public or private procurement / well developed demand Reaching financial sustainability Retreat of supporting actors (e.g. NGOs) and resources (e.g. subsidies) Formation of a viable business environment (e.g. achieving a regulation change)
F6	Resource mobilisation	Availability of funds for initial investments (e.g. research, feasibility studies) Availability of local finance and viable financing models (e.g. micro credits) Availability of human capital Level of satisfaction with the amount of available resources
F7	Creation of legitimacy/counteract resistance to change	Level of education of the end consumer with regards to the innovation Public opinion towards the innovation / prevalent pro/contra arguments Advocacy activities / providing legitimacy (e.g. for certain technologies, financial support, favourable regulations, tax exemptions)

Table 3.6 Proposed set of indicators for the seven functions

Combining all sources of information typically results in a qualitative description of the functional pattern where the functions serve as a way to structure the acquired information. With the so-called process approach it is also possible to map functional patterns in a quantitative way by counting the number of events related to a certain function (Negro, et al., 2007). This approach may be adequate to track functions over a longer period of time and where relevant events are well documented.

3.3.5 Step 4: assessing the functionality of the TIS

After assessing the functional pattern that describes *how* the TIS is functioning, the performance of the TIS has to be assessed i.e. *how well* the system is functioning (Bergek, et al., 2008a). This is a major challenge as functions are not expected to behave in a linear fashion. Different functional compositions may therefore lead to a similar systems performance and vice-versa. In order to determine if a certain system is functioning good or bad, some kind of reference point is needed.

One possibility is to compare the functional pattern of different settings such as regions for example. Assuming that those settings develop a similar functional pattern over the time, the functional analysis may for example provide insight about which settings are more developed and therefore a more

suitable environment for a certain innovation. In the context of WASTE this kind of analysis may be particularly useful if one out of several locations has to be chosen for the further development and introduction of an innovation.

Another approach is taking different phases of development as a reference point. A TIS can then be judged with respect to the individual functional requirements of each phase. Bergek et al. (2008) distinguish between a formative phase that requires extensive entrepreneurial experimentation and a growth phase where the focus shifts to expansion and large-scale diffusion through strong market creation. Hekkert et al. (2011) further refine this distinction by adopting the five steps of the classical diffusion-curve and suggest reasonable functional patterns for each step. Figure 3.5 illustrates these steps along with suggested functional patterns. Important functions and relationships are highlighted.

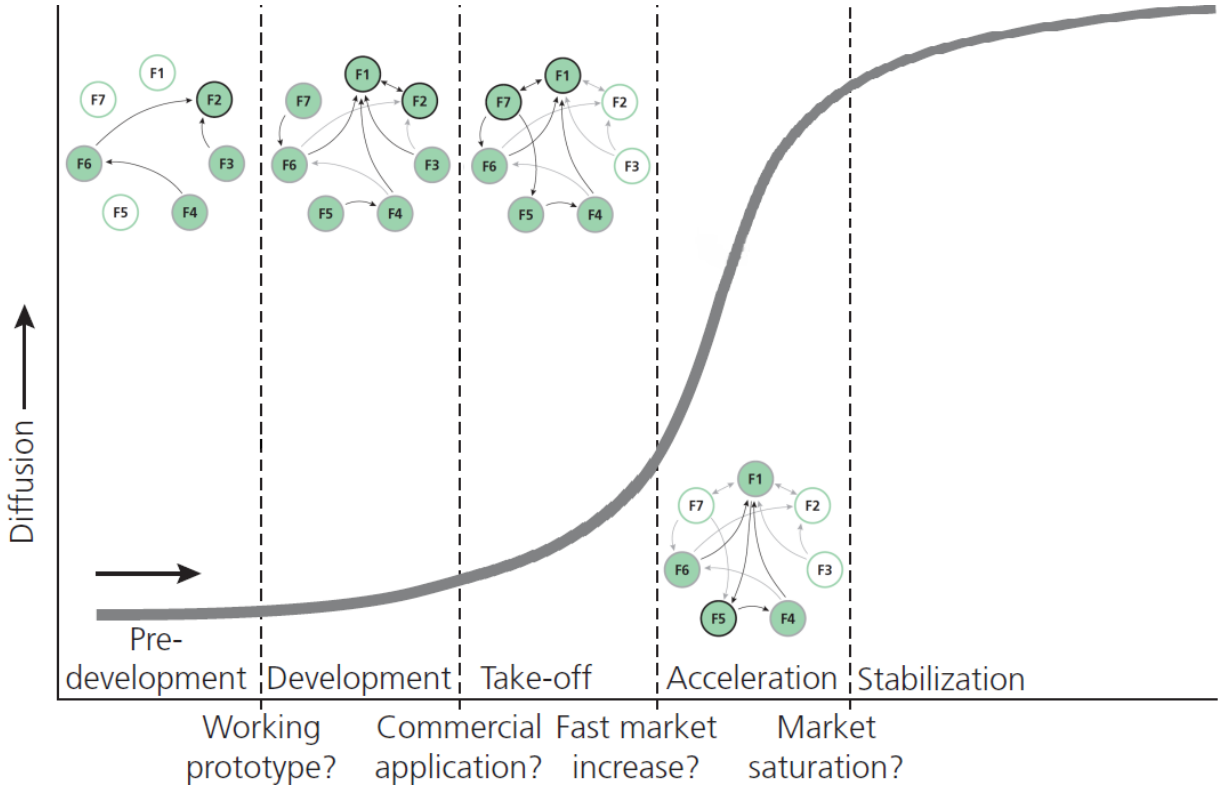

Figure 3.5 Phases of development and their functional patterns (adapted from Hekkert et al. (2011))

At this point, the nature of the development stages and their functional patterns is however not sufficiently researched or verified. Furthermore, it is expected that functional patterns may differ considerably between different kinds of TIS (Bergek, et al., 2008). Further research has to be done in order to gain more context-specific insight about the functional patterns in different phases of development.

3.3.6 Step 5: identify inducement and blocking mechanisms

After assessing the functionality of the TIS the mechanisms that led to its performance have to be identified. A basic distinction between *inducement mechanisms* that foster the development of one or several functions and *blocking mechanisms* that hinder their development is made. These mechanisms can be found within the TIS as well as outside of the TIS and may have a direct or indirect influence on one or several functions. Furthermore, they may influence and reinforce each other (Bergek, et al., 2008).When conducting an analysis, it is important to only include the linkages that are most

important in the specific context (Bergek, et al., 2008a). Surprisingly, literature gives little advice on *how* to identify blocking and inducement mechanisms. This is rather done intuitively, based on the information and deliberations from the previous steps of the FIS analysis. It is aimed to gain more insight about that with the help of the case work in the following chapters.

3.3.7 Step 6: specify key policy issues

Based on the previous five steps, key issues for improving the performance of the TIS by strengthening or adding inducement mechanisms and weakening or removing blocking mechanisms can be specified (Bergek, et al., 2008). These key issues can be useful to assess which actors and resources are required and how to achieve a desired change in the most efficient manner. Current FIS related literature provides however little guidance on how to identify and prioritise those key issues, especially in a business in development perspective. Humphrey et al. (2014) identified three critical questions that are addressing this issue and may serve as overarching guidance in this context:

- *How aligned are business and development goals, what drives the degree of alignment on the basis of the logics of interest and appropriateness, and what are the potential limits to increasing this alignment?*
- *What interventions are most likely to work under different conditions? How should such interventions be prioritised?*
- *How to deliver large-scale and enduring impacts through these interventions?*

(Humphrey, et al., 2014, pp. 18-19)

Based on these questions and considering the desired scope and involved actors of an intervention one or several intervention strategies may be developed.

3.4 Summary

Aim of this section was to give an overview about the concept of TIS and the FIS and to put it into the context of our research. By reviewing various FIS analyses in literature, a variety of approaches could be identified of which some may be particularly useful for the context of WASTE and to provide guidance for the case work in the following chapter. At some points, existing WASTE approaches may be integrated in the FIS analysis. Several areas of the FIS still need further investigation as they have not been sufficiently covered in literature so far. Two major reasons for that is the prevalent focus in FIS literature on renewable energy technology on the one hand and policy makers as a primary target group on the other hand. The following aspects in particular have to be further explored in the following chapters:

- Exploring the usefulness of the various approaches presented in step two to identifying and assessing the structural components
- Investigate how to assess the functionality of a TIS especially in the context of sanitation and development and gain more knowledge about functional patterns in the different development stages of a TIS
- Gain more experience in identifying blocking and inducement mechanisms and specifying, prioritising and operationalising key policy issues/strategies

4 Methodological aspects of the exploration phase

In the previous chapter, existing literature related to the FIS approach was reviewed as a base for the practical-oriented exploratory phase of this research. This chapter briefly describes how the application of these approaches and concepts was explored in the context of the WASTE working environment. The case descriptions following in chapter 5 and 6 then provide deeper, case-specific insights and illustrate the possible outcomes of such analyses. In chapter 7, the best practises that emerged from this exploration phase are discussed and used to design a customised WASTE manual for the TIS approach. The exploration process can be divided into two phases that are conducted in an iterative way: information gathering and the analysis.

Following recommendations in literature, meetings of various length and semi-structured interviews with key informants (20-40min.) constituted an important element of the information gathering process. Engaging in a dialogue with the respondents allowed to better understand their individual concerns within the respective topic and to seek clarification where necessary. The steps of the FIS approach and in particular its seven functions were used as guidance. This allowed for more structured information gathering and to make sure that important aspects were covered. On the other hand, enough flexibility was left to investigate areas of special interest, serving the explorative character of this research. Depending on the meeting situation and the given time frame, talking points were prepared upfront in written form or just dynamically applied when suitable e.g. during very brief or spontaneous meetings. Accordingly, not always all of the aspects described below have been discussed. Instead, the focus was put on a specific area of expertise or filling certain information gaps. Longer interviews were recorded if possible, to make sure to not miss out any details. Otherwise, notes were taken. The following steps apply to an in-depth semi-structured interview with a length of 20-40 minutes: After a brief explanation of the overall goal of the analysis, interviewees were asked to describe the TIS and its actors, networks and institutions and to define their own position within the TIS. Some interviewees had also the possibility to comment on data that has already been collected from previous interviews in a second step. Taking their position within the TIS into consideration, interviewees were then asked about the seven functions. Initially, the set of indicators that I illustrated in section 3.3.4 was used as guidance through these functions-related questions. This however quickly turned out as not very suitable. Respondents limited themselves too much to the specific indicators mentioned and had difficulties to grasp the overall concept of the functions. A brief description of the respective function along with open questions about activities and the perceived performance of the function yielded much richer information. The FIS manual described in chapter 7 reflects these findings.

Similar to the suggestions in literature (cp. Bergek, et al., 2008), key informants were identified using the snowballing method. Existing contacts and networks within WASTE served thereby as an efficient starting point. In both cases, already few key respondents were able to provide a quite comprehensive insight into the respective topic. Further interviews and written information such as reports, brochures etc. were then used to further refine and validate the gathered information. Besides case-specific information, also aspects about the FIS approach itself were captured to be considered for the design-phase, for example if interviewees had difficulties to understand or answer certain questions. The information was then summarised and structured during the analysis. The structure of the FIS supported the process of structuring. When summarising information, special attention was given to not only representing mainstream opinions but also retaining contrasting and diverging views. This turned out to be crucial for the functional analysis.

The six steps along with the several approaches that were elaborated in chapter 3 served as a foundation and starting point for the analysis. Some of the parts of the FIS approach could be intuitively adapted and easily applied to the two cases. For other parts, some adaptation was needed or it was required to choose between different available approaches by trial and error and with the help of continuous feedback from experts. Parallel to the JAGRAN case, a "conventional" pre-feasibility study was conducted that supplemented the exploration process with additional insights and by serving as a comparison base. Due to these adaptations and choices made, one will already notice some differences in the approach used in the following chapters compared to the six steps described in chapter 3. In chapter 7 I will discuss these differences in more detail along with the resulting design choices made.

5 Opportunities and barriers for innovations in the emergency sanitation sector

The sanitation infrastructure in emergency situations is often inadequate and a risk to people's health. Governments, NGOs and humanitarian organisations are getting increasingly aware of the importance of adequate sanitation in emergency situations. However, too little innovation has been taking place in recent years in order to address this issue (Bastable & Russell, 2013). Among others, WASTE identified this issue and aims at developing the emergency sanitation sector.

In this chapter the opportunities and barriers for innovations in the emergency sanitation sector (ESS) will be explored using the FIS approach. After giving a brief overview of the ESS as such I will follow the six steps that were elaborated in the previous chapters. Relevant technologies will be explained in more detail along the way if necessary.

5.1 Sources of information

Various sources of information are used aiming for a comprehensive and differentiated overview of the ESS. WASTE is well-connected with major experts in the ESS of which several were contacted. Seven have been selected for an in-depth interview based on their expertise in Emergency Sanitation, availability and to cover the topic from the perspective of different organisations and positions.

Organisation	Function/assignment of the interviewee
Loughborough University	Leader of teaching programmes in the Water, Engineering and Development Centre with particular focus on water and sanitation aspects in humanitarian situations; emergency preparedness and emergency response
WASTE	SAWI consultant; WASTE responsible for the S(p)eedkits project
WASTE	Sanitation consultant; WASTE responsible for the Emergency Sanitation Project
Netherlands Red Cross	Senior emergency field worker
Netherlands Red Cross	Advisor for water, sanitation and hygiene (WASH)
IFRC	Research officer Shelter Research Unit (SRU)
Oxfam GB	Emergency Sanitation Researcher

Table 5.1 Overview of interviewees

Besides, WASTE has access to a comprehensive collection of secondary information about emergency sanitation such as brochures, catalogues, reports etc. Especially reports of joint projects aiming at improving certain aspects of the ESS are a useful addition to the information gained in the interviews. Most notably are the outcomes from the international Emergency Sanitation Workshop held in June 2012 in Delft. Organised by a consortium of various organisations, it was the first of its kind, bringing a wide range of manufacturers from the private sector, humanitarian organizations, NGOs and researchers together for three days in order to discuss the challenges and opportunities in emergency sanitation (SuSanA, 2012). Other sources such as websites, online databases, discussions and visiting the emergency aid trade fair AidEx 2013 in Brussels further helped to get an impression of the ESS, to structure the analysis and to verify information.

This chapter is structured as follows: After a brief introduction about emergency sanitation, the ESS is analysed based on the six step approach that was presented in the previous chapters including boundary setting, a functional analysis and the identification of blocking and inducement mechanisms. Finally, the chapter illustrates some key policy issues that can be deducted from the analysis.

5.2 What is emergency sanitation?

In the context of emergency aid, the term 'emergency' may be defined as "result of a man-made and/or natural disaster, whereby there is a serious, often sudden, thread to the health of the affected community which has great difficulty in coping without external assistance" (Harvey, et al., 2002, p. 2). A vast majority of these events take place in the global South. Most recent examples for emergency situations are the Philippines typhoon disaster, the civil unrest in Syria or tension and violence in South Sudan and the Central African Republic, altogether affecting more than 26 million people (UN OCHA, 2014). In 2012, humanitarian response worth US$17.9 billion was given of which 28% (US$5.0 billion) are private voluntary contributions and 72% ($12.9 billion) contributions by governments (GHA, 2013).

Emergency situations can be very different in nature and may last a few weeks, several months or even several years. Among organisations active in the field, a common distinction between the three stages immediate, short term and long term is made. The immediate phase starts directly after the impact phase of a disaster, typically lasts 1-2 months and is typified by great instability and often high mortality. The short-term phase is characterised by stabilisation and typically lasts up to six months and the long-term phase describes the period of recovery taking up to several years (cp. Harvey, et al., 2002).

For sanitation in this context, the WHO provides a commonly used definition as "the means of collecting and disposing of excreta and community liquid wastes in a hygienic way so as not to endanger the health of individuals and the community as a whole" (WHO, 1987). Wider definitions of sanitation also include other important aspects such as solid waste management, medical waste management or disposal of dead bodies for example. These will however not be in focus of this analysis. To summarise, emergency sanitation can be briefly defined as "safe capture, collection and disposal of human excreta in emergency situations".

5.3 The FIS analysis

In this section, the ESS will be analysed following the six steps of the FIS approach that was presented in the third chapter.

5.3.1 Step 1: Defining the TIS in focus

The description of the ESS gave already some indication about the scope of the TIS in focus. It can be however further specified by taking technological aspects and the characteristics of various emergency situations into account. Most importantly, the TIS should align with the scope of SAWI and its guidelines of just supporting solutions that are sustainable and for which no appropriate local solution already exists.

There are various existing practises and technologies in the emergency sanitation sector of which some have been widely used in the past whereas others are in an early concept phase or just have been rarely adopted so far. Most wide-spread solution is a pit latrine. It is very cheap, easy to set up and little material (i.e. a pit slab) is required. It furthermore covers the whole sanitation chain as the human excreta are naturally decomposed on location. We can conclude that all areas where it is possible and safe to dig a pit can be excluded from the TIS due to the fact that a viable local solution already exists. However, there are common scenarios where pit latrines are not feasible:

- Surface unsuitable for digging (e.g. rocky surfaces)
- Flood-prone areas and areas with high ground water table not safe for digging (risk of contamination)

- Densely built-up areas with no space to dig
- Regulatory issues (e.g. land ownership)
- No time to provide a pit latrine (in the initial period of an emergency)
- Insecurity concerns (e.g. night time, women)
- People with special needs (e.g. children, elderly, people with limited mobility)

Table 5.2 gives an overview of alternatives to pit latrines that may be used in the above-mentioned scenarios. However, not all variations of these technologies should be considered in the TIS. From WASTE perspective it is important to just include solutions that meet certain sustainability criteria. Critical aspects in particular are insufficient safety, high water usage and if special disposal is required (e.g. chemicals, non-biodegradable plastic). Besides, some challenges of the mentioned technologies are pointed out, indicating considerable room for innovation and improvement in the ESS.

Technology	**Options**	**Challenges**
1) No-toilet solution Plastic bags for one-time or multiple use	- Use of (semi-)biodegradable material - Suitable interface (e.g. bucket) - Solidifying additive (e.g. powder, pad) - Urea as additive for accelerated sanitising/decomposition	Not always culturally acceptable, poor interface and user experience, collection and disposal required, high costs with the biodegradable option
2) Mobile toilet solutions for individual use	- Use of chemical additives preventing odour/gasification - Use of natural additives (e.g. sawdust) to prevent odour and support decomposition - Use of urine diversion to decrease waste volume / increase re-use opportunities - Use of enzymatic treatment	Proper use has to be ensured, maintenance collection and disposal required, environmentally acceptable disposal of chemical additives very challenging
3) Communal toilets with tank	See 2) - Integrated or larger external waste tank emptied with vacuum pumps (Porta Loo) - Detachable waste tank under a superstructure (raised latrine)	High costs, collection (with vacuum pumps) and special treatment/disposal required, sufficient space needed
4) Communal toilets with septic tank		Sufficient water for operation required, capacity limitations, considerable space needed
5) Overhung latrine	- Latrine superstructure built over water (e.g. river, lake, sea)	Inappropriate in most situations due to contamination of surface water
6) Raised pit latrines	- Urine diversion - Ventilation - Alternating use of two pits	High costs, sufficient space needed
7) Sewerage-based solution	- Connecting new (public) toilets to existing sewerage - Repairing existing sewerage	Functioning sewerage often not present, good water supply needed, sewerage treatment must be functioning

Table 5.2 Overview of alternative technologies for emergency sanitation

To conclude, the TIS in focus may be briefly defined as “safe and sustainable sanitation solutions in emergency situations where pit latrines are not suitable”.

5.3.2 The sanitation chain of emergency sanitation

Primary objective for SAWI to engage in the field of emergency sanitation is to establish a functioning sanitation chain and/or enhancing its performance by facilitating the introduction of innovations to this sector. For this reason, the existing sanitation chain is briefly examined in this section. The focus lies thereby on pointing out common features in the first and second phase of an emergency.

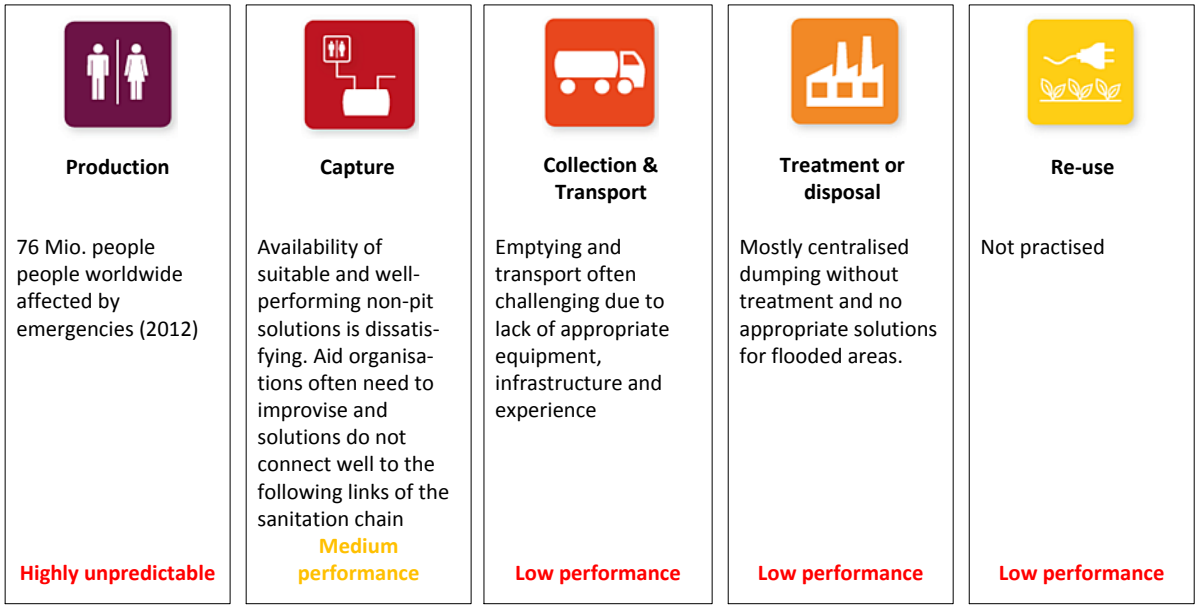

Figure 5.1 Typical features of the sanitation chain in emergency situations

Figure 5.1 illustrates typical issues of the sanitation chain in emergency situations. It can be seen that all links of the sanitation chain show needs for improvement. A satisfactory strategy from a SAWI perspective should aim at addressing at least some of these above-identified key issues when supporting an innovation for the emergency sanitation sector. The solution should thereby adhere to the WASTE/SAWI guidelines.

5.3.3 Step 2: Identifying the structural components

The field of emergency sanitation is a quite unique set-up that differs a lot from 'conventional' sanitation settings and consists of a variety of structural components (i.e. actors, networks and institutions) that are briefly characterised in this section. When necessary, a further in-depth analysis of certain components is conducted during the functional assessment.

Emergencies are hardly predictable regarding their occurrence, impact and location and the users of emergency sanitation can be located anywhere in the world where an emergency strikes. Local and international aid organisations such as the Red Cross for example are primary actors during the immediate and short-term phase of an emergency. Funded by private donations and contributions from governments they travel to affected regions to provide relief. Towards the long-term phase of an emergency more and more other organisations such as government bodies or (re-) development oriented NGOs may get involved albeit that this is not always the case. Besides these immediate actors various others complement the ESS. Universities but also specialised organisations (e.g. WASTE, German Toilet Organisation) conduct R&D on sanitation related technology and practises, promote (new) practises and technologies and coordinate between various actors e.g. in joint projects. The private sector provides products and materials and may be also involved in R&D and promotion activities.

The humanitarian sector is well-connected by various networks. First of all, humanitarian organisations have networks on their own, connecting for example regional and national chapters on an international level. Umbrella organisations such as UN OCHA coordinate humanitarian affairs on a global level. Besides, there are several sanitation-related networks for knowledge exchange between humanitarian organisations and other stakeholders such as the global WASH cluster or the Sustainable Sanitation Alliance (SuSanA). Recently, also emergency sanitation specific networks emerged in form

of joint projects such as the EU-funded S(p)eedkits programme or the 2012 SuSanA workshop on emergency sanitation in Delft.

The Emergency Sanitation project is a collaboration between IFRC, WASTE and Oxfam that aims to increase the global understanding of current and future emergency sanitation and to propose new concepts and modular technologies for safe excreta disposal in emergency settings that are applicable in a variety of situations. It is funded by US Aid and runs from 2012 until 2014 (ESP, 2014).

S(P)EEDKITS is a European collaborative project with partners from several disciplines funded by the European Union. It aims at analysing the emergency response units of humanitarian organisations on their strengths and shortcomings and then developing innovative solutions in the areas of shelters, water & sanitation and infrastructure (SPEEDKITS, 2014).

Despite its variety of locations, actors and networks, some universal institutional factors can be identified. Political stability, demographics and environmental developments (e.g. global warming) are factors that influence where, how and with what kind of impact emergencies occur and therefore define the needs for emergency sanitation. Also from an organisational perspective the needs for emergency sanitation can be defined, for example by agreeing on goals and minimum standards for humanitarian response as done in the Sphere Project (The Sphere Project, 2011). A further institutional factor is the general perception of the themes aid and sanitation in society that influence donations as well as the interest for related education and careers. Finally, the overall logistics are treated as an institutional component, imposing boundaries on the TIS regarding price, capacity, time and regulations in order to get needed items to emergency locations. Figure 5.2 provides an overview of the aforementioned actors, networks and institutions.

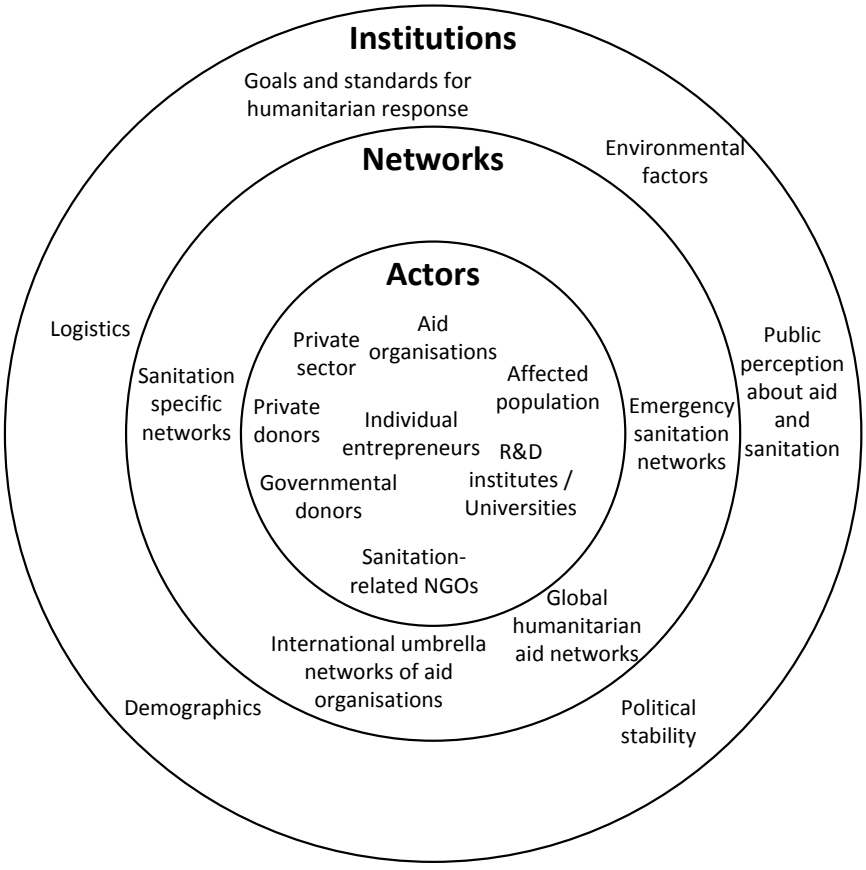

Figure 5.2 Overview of important actors, networks and institutions in emergency sanitation

In order to get further clarity about the structural composition of the TIS, these actors, networks and institutions may be grouped according to their role(s) in the TIS. These proposed groups are not mutually exclusive as some components fulfil more than just one role in the TIS.

The *demand* group primarily consists of national and international humanitarian organisations purchasing products for emergency sanitation. The individual users, in this case the people affected by an emergency are deliberately not placed in this group. In the current TIS of emergency sanitation they cannot or just indirectly (e.g. through demand analyses) influence the purchasing decisions for sanitation solutions during the immediate and short-term phase of an emergency.

The *supply* group mainly consists of firms of the private sector and is concerned with manufacturing and supplying of emergency sanitation products. Typically, the private sector also provides maintenance and service for its products. This is however not the case in the ESS. This task is either not necessary, taken up by the aid organisations on-location or neglected.

Another group of activities can be characterised as *research and education*. It mainly encompasses the research and teaching/training departments of universities and humanitarian organisations but also few individual entrepreneurs and enthusiasts that are concerned with emergency sanitation.

Other structural components are influencing (aspects of) the overall performance of the TIS in various ways. I propose to distinguish thereby between internal influencers that allow the possibility for trait-making (i.e. factors within the area of influence of actors of the TIS) and external influencers that are realistically not subject to trait-making activities by the TIS (e.g. natural phenomena, global trends etc.) but that have to be anticipated in the innovation process. In the ESS, the group of *internal influencers* includes organisations such as WASTE and the above-identified networks in their role as intermediary between the different parties of the TIS.

Many of the *external influencers* are well-described in the concept of the *socio-technical landscape* containing "a set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems" (Geels, 2002, p. 1260). Besides these landscape factors however, also other actors and TISs outside of the TIS for emergency sanitation should be included in this group as they can have a similar effect on the innovation process. As an example, the TIS of biodegradable plastics is supposedly very hard to influence from the perspective of the ESS. A breakthrough in this TIS could however completely change the dynamics within the TIS of emergency sanitation. In this special context of emergency sanitation, also the users may be assigned to this group. They can hardly be addressed by the TIS prior to an emergency but influence the TIS regarding requirements of a suitable emergency sanitation solution. Not all identified structural components can be clearly assigned to either the group of external or internal influencers. It is subject to discussion to what extent logistics, public and private funders, the overall perception and funding of aid and standards, rules and regulations can be influenced by the TIS of Emergency Sanitation. As an example, aid organisations may be able to optimise their own logistics but they are still bound to external factors such as fuel prices or size restrictions of available airplanes. For this reason, these components are placed in-between internal and external influencers. Figure 5.3 illustrates the different roles within the TIS of Emergency Sanitation. Whereas the separation between actors, networks and institutions helped in the previous step to identify important elements of the TIS, it is not seen as very important for the grouping of the elements. Therefore, and to reduce the complexity, the figure does not separate between actors, networks and institutions.

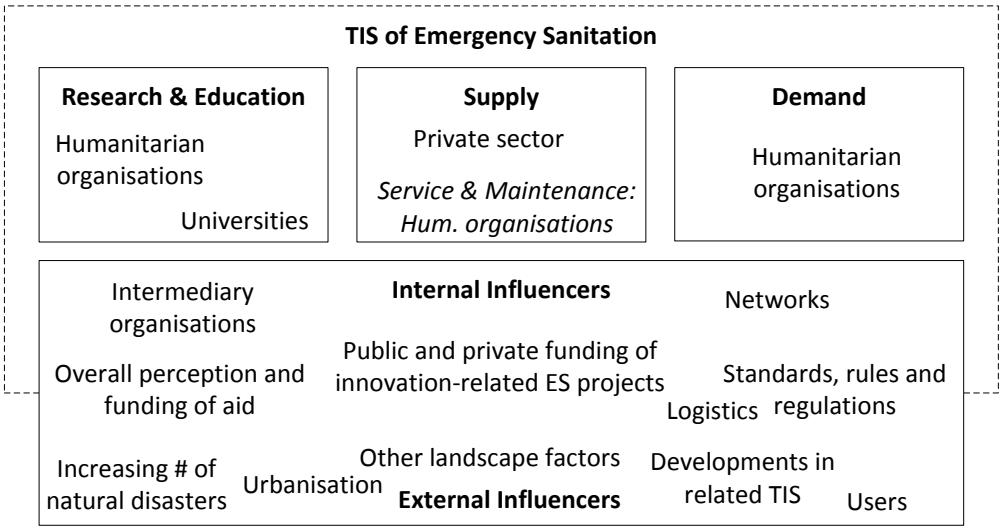

Figure 5.3 The roles within the TIS of Emergency Sanitation

By picking up the concept of enactors and selectors that was introduced in section 3.3.3, it is already possible at this stage of the analysis, to envision several scenarios on how the introduction of an innovation in this TIS could be achieved. One or several scenarios may be part of a strategy that is formulated based on this analysis. The functional analysis following this section may provide further insights about the desirability of certain enactor-selector configurations.

One possible scenario is the supply-driven approach as it can be observed in case of Peepoo. The supplier (i.e. a firm in the private sector) is the enactor, proactively developing and offering a solution. The humanitarian organisations act as selectors, deciding about the procurement and adaptation of the offered solution. In a second stage, the user acts as selector, accepting or refusing the solution in case of an emergency.

Peepoople is a Swedish-based company that is concerned with the production, marketing and sales of their self-developed toilet solution Peepoo. The company is currently building up mass production aiming at a monthly capacity of up to 12 million Peepoos by 2014. Peepoople is distributing Peepoos through local NGOs to urban slums and through governmental or aid organisations in emergencies (Peepoople, 2014).

Peepoo is a personal single-use self-sanitising and fully biodegradable toilet targeted for the use in densely populated areas that lack proper access to sanitation. It consists of a double-layer biodegradable bag that is coated with a film of urea in the inside. After use it is closed with a knot and stored for 4 weeks. During this period, the urea reacts with the faeces and urine and inactivates disease-causing microorganisms, bacteria, viruses and parasites. It is then buried and acts as fertiliser (Peepoople, 2014).

According to the Oxfam equipment catalogue, Peepoo bags for emergencies currently retail for GPB 3190 for 28,000 bags covering 1000 people (200 families) for 28 days (~0.14€ per use). Each personal pack of 28 Peepoos also contains a bag for collecting and disposing of used bags. The pack furthermore includes 200 potties (one for each household) specifically designed for use with Peepoo bags (Oxfam, 2014).

Figure 5.4 Peepoo bag (Oxfam, 2014)

Another option is a demand-driven approach. Humanitarian organisations but also intermediaries can take the enactor role by commissioning firms of the private sector to develop and produce solutions for

emergency sanitation according to given specifications. In the current TIS this approach can just be observed to a small extent. It is mainly limited to the purchase of (slightly modified) off-the-shelf products by humanitarian organisations. Third option is a finance-driven approach as it can be partly observed in current emergency sanitation related joint projects. Neither humanitarian organisations nor firms are taking the enactor role, but a third party providing funds along with terms for their use related to emergency sanitation. Besides these, also other more complex scenarios are possible where the roles dynamically change over the time. Triggered by general funding, an intermediary organisation such as WASTE could for example invest resources to assess and promote opportunities for the private sector in emergency sanitation. This in turn could motivate firms to develop a solution for this market. Finally, a humanitarian organisation could decide to test and adopt this solution, triggering other organisations to follow. In this example, the enactor role moves from the financier to an intermediary organisation (internal influencers) and from there to a firm (supply) and finally to a humanitarian organisation (demand).

5.3.4 Step 3: Mapping the functional pattern of the TIS

After identifying the structural components of the TIS in the previous section, this section is concerned with the assessment of the seven system functions that have been introduced in section 3.2.

F1: Entrepreneurial activities

Various types of entrepreneurial activities can be identified around the ESS. The private sector is involved in several ways. Some companies are developing and experimenting with solutions for emergency sanitation as part of joint projects such as S(P)EEDKITS or the Emergency Sanitation Project. As these activities are heavily subsidised, the entrepreneurial ambitions are quite limited and these companies are more in the role of a contractor, fulfilling pre-defined assignments. Little is done to sustain these activities after the end of the project and move to the next phase independently. Another group of companies is actively exploring new market opportunities and is seeing the ESS as a potential market segment for existing or new products. They are however just allocating little resources, so that these activities do not go beyond the creation of concept papers. Only two companies that are conducting more substantial entrepreneurial activities, Evenproducts and Peepoople, have been identified. Evenproducts extended its existing product line of pit latrine related solutions with a raised pit latrine designed for emergency situations. The innovativeness of this new product is however very limited and important issues such as high costs and emptying full pits have not been addressed. Peepoople with its product Peepoo has been mentioned by many interviewees as the only “real” innovator in the field of emergency sanitation. The company has been described as being very proactive with regards to promoting and large-scale testing of their innovation in emergency situations, developing accompanying by-products and a strong focus on achieving mass production along with a viable business model.

Besides companies, few individual entrepreneurs could be identified that are designing and experimenting with new solutions for emergency sanitation. These solutions are however in a very initial stage, far away from financial viability and mass production. Within the Emergency Sanitation Project, design contests have been organised in order to support some of these entrepreneurs to further pursue their idea by providing price money and offering relevant internships. Finally, also WASTE is taking an entrepreneurial role in emergency sanitation. By developing expertise in emergency sanitation, it sees the opportunity to provide matchmaking and consultancy services to the private sector as well as the humanitarian sector.

To conclude, it can be seen that some variety of entrepreneurial activities take place in the ESS. However, many of these activities remain in an early stage and are heavily subsidised. Little attention is paid aiming at business development and large-scale employment. Only one actor, Peepoople could be identified, that is proactively and substantially innovating and developing a business targeted at emergency sanitation.

F2: Knowledge development

The group of actors engaged in knowledge development related to emergency sanitation has been characterised as rather small. Emergency sanitation related academic research is taking place in several disciplines. Some universities such as the London School of Hygiene (UK), UNESCO-IHE (Netherlands) or Loughborough University (UK) have small research departments that are dedicated to topics related to water & sanitation of which some amount of research activities is related to emergency sanitation in particular. However, also other disciples such as construction engineering or industrial design for example dedicate sporadic research projects to emergency sanitation related issues. Experts pointed out some weaknesses within the academic research. In their perception, research often lacks demand-orientation and a clear link to later applicability. Some reasons for that mentioned were:

- Research is influenced by funding (e.g. to meet donors' requirements)
- Too narrow view by mainly focusing on the own discipline
- Research based on preconceptions instead of substantial knowledge about the context and actual needs

Humanitarian organisations such as the IFRC or Oxfam have own research units where research is mainly conducted by practitioners with field experience. As these units have a relatively small capacity, it is common to involve other aid organisations, consultants, companies or designers in the research activities. According to experts in this field, scientific output from universities is however rarely considered. Due to poor knowledge management, just little of the learning-by-doing knowledge acquired during field missions could be utilised in the past (Visscher, 2012). The R&D activities are therefore mainly based on individual experience and perceptions of the researchers. The already mentioned joint projects Emergency Sanitation Project and S(P)EEDKITS are very recent efforts to stimulate interdisciplinary knowledge development in the ESS. The output of these projects until now has been however assessed as relatively low.

To conclude, it can be seen that a certain variety and capacity of knowledge development is present and also interdisciplinary research is increasingly getting attention. On the other hand, several weaknesses could be identified.

F3: Knowledge diffusion

The knowledge diffusion within the ESS has been characterised unanimously as well-functioning. One reason for this is its very manageable size in which information can quickly spread. Several sanitation-related networks and regular events enable a good knowledge exchange between organisations. Well-established sanitation-specific training programmes organised by aid organisations and universities ensure the dissemination of knowledge among sanitation experts and field workers. According to experts, the ESS has a very open attitude towards innovations and as soon as few key persons are convinced by and adopt an innovation, it would quickly disseminate. Through organisations such as WASTE, also external actors such as companies can gain access to this network relatively easily. It

can be however assumed that many companies and other potential stakeholders are not aware of these networks and opportunities and miss out on acquiring relevant knowledge entirely.

F4: Guidance of search

With regards to general developments, a broad agreement among the actors could be observed. Humanitarian organisations are increasingly aware of the importance of good sanitation in emergency situations as a complement to providing clean water and in order to maintain health, safety and dignity. The Sphere Project has been setting minimum standards for humanitarian response (The Sphere Project, 2011). Trigger events such as the 2010 earthquake in Haiti furthermore increased the awareness for the importance of solutions that are suitable in cases when it is not possible to deploy pit latrines. Due to global developments such as urbanisation and climate change it is broadly anticipated that the number of disasters in settings not suitable for pit latrines (e.g. flooded areas, densely populated areas) is increasing considerably and appropriate solutions are needed. The "guidance of search" function is however by no means well-developed and several issues could be identified.

With pit latrines as prevalent solution, sanitation used to be very cheap in the past and humanitarian aid organisations are still looking for solutions that meet a very tight budget. In contrast, the requirements for sanitation solutions have been increasing. Solutions have to be suitable for difficult environments such as densely populated or flood-prone areas. Furthermore it is aimed to move away from short-term solutions towards solutions that are contributing towards a (re-)development of the affected area. Meeting both of these requirements simultaneously seems rather unrealistic from an innovator's perspective. Besides, there is a lack of a clear vision and understanding about how ideal solutions for emergency sanitation should actually look like. A variety of schools of thought have been mentioned by the interviewees as illustrated in Table 5.3.

Moving from emergency camps towards on-site aid	Putting people into emergency camps is considered inhumane and should be avoided at all costs. Instead, aid should be provided in the people's habitual environment whenever feasible. Sanitation solutions should consequently focus on the recovery and use of existing infrastructure and fit well to the existing environment and practises.
Considering no-toilet options	No-toilet options such as the use of bags could be a viable alternative especially if people have been relying on alternative concepts such as the "flying toilet" already before an emergency. Some stakeholders oppose this solution as being insufficient.
Technology-oriented vs. service-oriented solutions	Whereas some stakeholders favour solutions that are focused on technology, others advocate for integrated service concepts.
External relief vs. local development	Some stakeholders consider external relief items for short-term use as integral part of their strategy whereas others aim at avoiding these at all costs, focusing on local long-term development.

Table 5.3 Schools of thought in the ESS mentioned by the interviewees

It can be seen that there is no clear guidance of search but a variety of different visions leading to a lack of clarity about requirements and market potential.

F5: Market formation

The market for emergency sanitation can be divided into several categories. Some of the purchases of humanitarian organisations, considered as standard stock items, are done on a regular basis and put into warehouses so that they are immediately available for shipping in case of an emergency. Others

are purchased in case of emergencies based on pre-defined agreements about price and delivery times. These kind of items are listed in the organisations' catalogues following procurement and public tender procedures. Although partly unpredictable, this market segment can be considered as very well-developed. However, just a very limited selection of sanitation-related items can be currently found in the organisations' catalogues, mainly for the construction of pit latrines. Just recently, Oxfam added Peepoo bags to its catalogue as a first more innovative product. The procurement procedure itself is a high entry barrier as it is cumbersome and connected with high uncertainties. Even if a fruitful cooperation between humanitarian sector and the private sector results in a good, demanded product, this does not ensure that this product will be instantly bought (de Haas, et al., 2013).

Another market category is international on-demand purchases that are highly unpredictable regarding location, volume and type of technology needed. This kind of market is typically limited to off-the-shelve products not specifically designed for emergency settings, which are available on short-term and in larger quantities. Lastly, there is a similarly unpredictable local market at the location of an emergency.

It can be seen that the current market is rather small and in large parts highly unpredictable. The example of Peepoo however shows that some market formation is taking place and that it is possible to create a market for an innovative product. However, as already indicated in the section *F4: Guidance of search*, little is known about the current and potential future market size of emergency sanitation related technology.

F6: Resource mobilisation

With regards to research and development, stakeholders described the amount of available financial resources, mainly by externally funded projects such as the earlier-mentioned Emergency Sanitation Project, as sufficient in order to develop innovative solutions. The funding has furthermore been described as not too restricting regarding setting own research goals. The situation regarding human resources has been described as more critical. Due to the nature of the job and limited career options in humanitarian organisations, the employee retention is rather low with the consequence that employees can just build up limited experience within the emergency sanitation sector. Only few people knowledgeable of emergency sanitation aspects emerge from academia.

Untypically, as emergency aid is financed externally, resource mobilisation is not only crucial during the start-up phase of an innovation. Also the operations of the aid organisations depend on external funding through governments and individuals. Some issues have been pointed out regarding this. Firstly, especially individual donations are highly dependent on the "popularity" of a disaster i.e. the coverage in media. Whereas some disasters are very well-covered, others occur largely unnoticed. Also, media interest and the willingness to donate usually diminish after the initial phase of a disaster so that the available financial resources decrease after some weeks. Secondly, there is often a limited flexibility on how money can be spent. As sanitation is still a less popular topic amongst donors, other sectors may receive over proportionally more donations. Besides, a bias towards technology-focused solutions has been described as it is easier to communicate purchasing of equipment towards donors than immaterial goods such as salaries and services.

F7: Creation of legitimacy / resistance to change

Two main user groups have to be distinguished for the analysis of this function: aid workers of humanitarian organisations responsible for deploying sanitation solutions in emergency situations, and end-users of the solution, the people affected by an emergency.

Due to the fact that just few innovations have been introduced to the ESS in the past, estimations about the acceptance remained speculative. The humanitarian organisations have been generally described as relatively open towards innovative solutions in sanitation. However, several experts stressed the importance that sanitation solutions should be easy to use and require little oversight and maintenance during their operation, as aid workers can just allocate limited time for it. Sanitation solutions that require a lot time to deploy and/or a larger amount of explanation and training to the end-users are expected to meet resistance.

As emergencies occur in a variety of locations and different contexts, it is difficult to get a general insight about the acceptance of a sanitation solution amongst end users. However, based on past experience of humanitarian organisations, some typical acceptance issues could be identified that may occur in an emergency setting:

- Permanent solutions may experience resistance due to land ownership issues etc.
- Lack of ownership
- If elements of a sanitation solution are suitable for other purposes, there is an increased danger of theft and repurposing
- (Western) out-of-the-box solutions may undermine local capacity building and increase the (feeling of) dependency. Solutions including local infrastructure, capabilities, services and cultural norms are less likely to experience resistance
- Aiming for a one-size-fits-all solution is likely to lead to resistance in certain settings. It is advantageous to have a variety of solutions available to address local needs in an optimal or at least acceptable way

5.3.5 Step 4: assessing the functionality of the TIS

After assessing the functions of the TIS individually, this section is concerned with a systemic analysis of the TIS, taking the overall functional configuration into consideration.

First step towards the assessment of the functionality of the TIS is the identification of its current development stage as it is assumed that each development stage requires a different functional configuration. Based on the considerations in section 3.3.5, a distinction between the phases pre-development, development, take-off, acceleration and stabilisation is made. Due to its rather broad definition, the ESS can be characterised as a quite multi-layered TIS in which several development stages can be observed. Overall, a majority of the developments observed are situated around a later stage of the pre-development phase and the early stage of the development phase where prototypes and promising technologies exist but they did not yet turn into commercially viable products. Prominent exception to this is Peepoo that already found its first commercial application. Figure 5.5 visualises the development stage of the TIS.

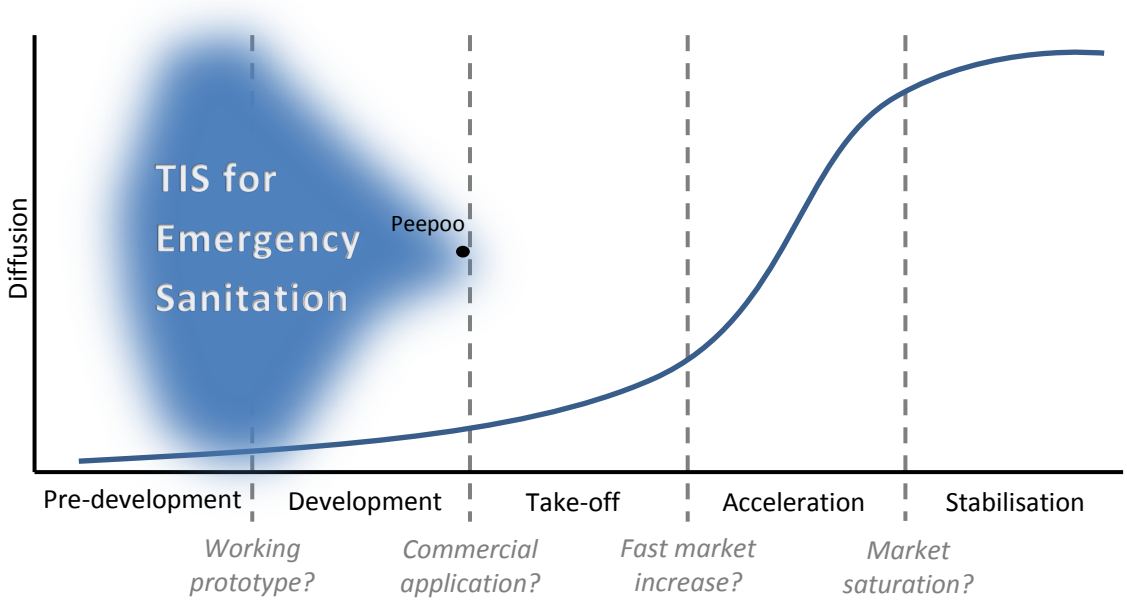

Figure 5.5 Development stage of the TIS for emergency sanitation (adapted from Hekkert et al. (2011))

In the second step, the essential functions for its current stage of development have to be identified. It is assumed that if all these identified functions are performing well, the overall development of the TIS is doing well. At the same time, it is important to recall that due to interdependencies, the performance of individual functions cannot simply be added up. Just one function with a poor performance may already hinder the overall development of the TIS. Current challenge of the TIS of emergency sanitation is developing prototypes and concepts towards commercial applications. Hekkert et al. (2011) suggest that *knowledge development* along with *entrepreneurial activities* may be the core functions enabling this. For these functions to perform well, sufficient resources as well as clear expectations and a common vision (i.e. *guidance of search*) are required. Other functions are considered to be of less importance but can be a good foundation for later developments of the TIS.

The poor performance of the *guidance of search* function can be clearly identified as a major barrier of the TIS of emergency sanitation. The lack of a clear vision and clarity about requirements and market potential leads to insecurity amongst potential entrepreneurs as well actors that are engaged in *knowledge development*. Especially *entrepreneurial activities* are however needed to bring the TIS to the next development stage and develop commercially viable applications. More focused *knowledge development* activities as a result from improved guidance of search can support this process. With respect to the development phase, *resource mobilisation* seems to have a less critical role and has been described as sufficient by several actors. The procurement procedures and the dependence on donors and earmarked donations indicate however possible barriers for later development stages of the TIS. Although it is assumed that the other functions are less critical for the current development stage, their performance can give an indication about the future development stages of the TIS and influence the expectations of various stakeholders accordingly. In terms of *knowledge diffusion*, good performance can be expected which gives good prospects for the take-off phase as information about innovations can quickly disseminate over the numerous existing channels and networks. The analysis of the *creation of legitimacy* function reveals important issues that should be already anticipated during the development phase in order to ensure the success of an innovation. The analysis of the *market formation* function revealed a high unreliability of the emergency sanitation market that should be addressed when formulating a strategy.

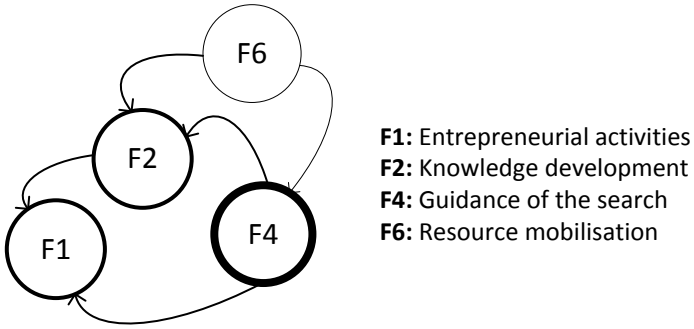

Figure 5.6 Illustration of the described functional configuration

To conclude, the overall performance of the TIS in the development phase can be assessed as rather low. One major reason for that is the poor performance of the guidance of search function that may be the reason for a low amount of entrepreneurial activities and uncoordinated knowledge development. Also an analysis of the other functions point out some issues that should to be anticipated when trying to achieve an optimal performance of the TIS in the long-term.

5.3.6 Step 5: identify inducement and blocking mechanisms

Based on the analysis of the TIS in the previous steps, important blocking and inducement mechanisms can be easily identified. These are summarised in Table 5.4. Besides, I suggest possible ways how these blocking and inducement mechanisms could be addressed. This results in a number of strategic options that may be adapted in order to improve the overall performance of the TIS.

Function	Blocking / Inducement mechanism	Possible ways to address mechanism
Guidance of search	No clarity about needs	Improve the knowledge management in organisations and systematically assess needs
	Humanitarian organisations aim for very cheap solutions	Create awareness for appropriate budgets Provide cheap solutions Find supporting finance
	Lack of clarity about market size	Conduct a joint demand assessment
	Lack of clear vision and long-term goals in the ESS	Jointly develop and promote common vision and long-term goals in the ESS
	General openness towards innovative products (e.g. Peepoo)	Develop compelling, innovative product (game changer)
Entrepreneurial activities	Concepts are not taken to the next step	Enable support/incentives to follow up on concepts
	Little incentives during projects	Design project set-up more result-based Increase incentives for entrepreneurial activities
	Increasing interest of firms in alternative (BoP) markets in general	Identify interested companies and match them with the ESS
Knowledge development	Overall low knowledge development capacity	Promote increased knowledge development Increase funding for knowledge development
	Research activities are scattered and lack focus	Set-up interdisciplinary joint projects
	Research guided by availability of funding/donations instead of demand	Lobby to align funding/donations to demand Explore other funding opportunities

	Little structured knowledge available from organisations due to poor knowledge management	Improve knowledge management in organisations and knowledge exchange with researchers
Resource mobilisation	Earmarked budgets donations with technology-focus	Promote more flexible and sustainable budgets and donations
	Low retention rate of emergency aid workers; staff with little experience	Adjust products accordingly Acquire skilled personnel
Market formation	Market highly unreliable	Explore procurement strategies that increase reliability Develop as a supplementary market for firms Develop products suitable for multiple markets besides the ESS
	Cumbersome procurement procedures	Evaluate and improve procurement procedures
Creation of legitimacy / resistance to change	Target group unknown in advance	Create variety of options to meet different needs and avoid resistance Aim for highest compatibility
Knowledge diffusion	Actors well-connected through various networks and events	Provide relevant stakeholders (e.g. firms) access to these networks/events

Table 5.4 Overview of inducement and blocking mechanisms

5.3.7 Step 6: specify key policy issues

In the previous step, numerous blocking and inducement mechanisms and possible ways to address these were identified. It is however neither realistic nor efficient to undertake all of these interventions simultaneously. The challenge is, to identify and prioritise those interventions that make best use of the limited resources available and achieve the greatest effect. These restrictions could be for example given by available funding programmes and financing options that define the budget and scope of the intervention. Each scope and budget may thereby require a different set of interventions and a different prioritisation in order to achieve the best possible result. For the selection and prioritisation of mechanisms that should be part of our strategy, we can draw an on the deliberations about the development stage and functional patterns made in section 5.3.4. The three questions presented in section 3.3.7 may serve as overall guidance.

As illustration I will elaborate on two possible strategies to improve the performance of the TIS: a product-driven strategy and a broader demand-driven strategy. Both could be typical projects initiated by SAWI / WASTE.

A product-driven strategy fits very well with the typical SAWI way of working. It aims at addressing the inducement mechanism of "openness of the ESS towards innovative products" along with well-performing knowledge diffusion by developing a compelling, innovative product. A good success case for such as strategy is the earlier-mentioned product Peepoo. WASTE could identify suitable suppliers and facilitate the development of such a product with help of their expertise and network. The impact of this strategy on the development of the TIS can be manifold and is not only limited to the impact of the product itself. Other entrepreneurs inside and outside of the ESS may be triggered by the success of the product and also engage in entrepreneurial activities. It may also have a considerable impact on the guidance of search function. With the introduction of the iPhone, to give a popular example, Apple achieved to focus and strengthen the guidance of search of the smart phone sector from a variety of rather unsuccessful solutions towards devices with a large touch screen, triggering a development from

a niche to a mainstream market. An innovative product for the ESS may have a similar effect. On the other hand, it is important to anticipate the high risk of such a strategy and blocking mechanisms such as "highly unreliable market". Markard & Truffer (2008a) distinguish between three strategies for companies of which two may allow to undertake a project under these conditions. Following a *leading strategy*, a company invests high resources and puts high priority on a project to become market leader. This strategy is rather unsuitable in this context due to the unreliability of the market. A product failure or a temporary lack of demand could easily endanger the overall well-being of the company. It is rather unlikely that a company is willing to take such a risk. More suitable is the *learning strategy* where the company's main motivation lies on establishing contacts and gathering experiences with medium resources and priority. This could be for example a larger company that sees the ESS as a side business and that would not affect the company too much in case of a failure. In any case, the company could gather experiences from such a project, for example in terms of innovative capability or personal development of their employees. Also the *image shaping strategy*, where the company is primarily motivated by improving the corporate image in terms of responsibility and innovativeness, could be an option. This strategy however carries the risk that too little resources and priority are dedicated in order to achieve a substantial impact. To conclude, it may be most promising to identify a supplier that is capable and willing to undertake such a project following a learning strategy.

A possible demand-driven strategy is somewhat broader compared to focusing on the development on one product. Central point of such a strategy is tackling the poor performance of the guidance of search function. This could be for example achieved by WASTE initiating a project together with several aid organisations and funders aiming at systematically assessing the demand, developing a common vision along with an appropriate budget and promoting this vision among relevant stakeholders. This could then trigger knowledge development and entrepreneurial activities and lead to the availability of a variety of improved technologies in the ESS. Compared to a product-driven strategy, this demand-driven approach is quite long-term oriented and may be challenging to achieve tangible results that clearly link back to the activities of such a project. On the other hand, this approach offers the opportunity for a broad long-term development of the ESS with the potential to bring substantial change into that sector.

5.4 Summary and methodology-related key lessons

This analysis of the Emergency Sanitation Sector resulted in a variety of insights. The process of defining the TIS helped to clarify the scope of research and provided a review about available technical options. Together with the second step, identifying the structural components of the TIS in focus and determining their role in the ESS, this can give the reader a good grasp of the ESS and allows a first identification of possible points for intervention under consideration of internal and external influencers. The functional analysis provided a structured overview of the trends and dynamics in the TIS and revealed that there are several deficits in the ESS that have to be overcome in order to further develop the ESS. Major deficits have been especially identified in the "Guidance of Search" function, hindering the overall development of the ESS. These findings could be translated into a range inducement and blocking mechanisms that allowed to come up with a variety of options for a strategic intervention. Depending on the given scope and resources these options for intervention can be prioritised. Two possible options for such a prioritisation have been presented: a demand-driven strategy and a product-driven strategy. Both strategies could be starting point for a project initiated by WASTE.

In terms of methodology, a variety of key lessons could be learnt about the application of the FIS. The first iterations of conducting interviews and the subsequent analysis revealed that explaining the

general concept of the functions and using open questions provides deeper insights than using a set of indicative questions only. Furthermore, it became apparent that contrasting and diverging opinions and insights, even if they just constitute a small part of the overall information, are crucial for the functional analysis. When summarising interviews and other data it is therefore important to ensure, that this kind of information does not get lost. As the analysis was not focusing on a certain product and location but on a whole knowledge field, the definition of the TIS was quite challenging. After some exploration I learned that a technology review can be very useful to overcome this challenge. Another challenge of this analysis was the integration of the concept of the sanitation chain. The initial thought, that it may be useful for the identification of structural elements turned out to be wrong as it was difficult to link it to all elements of the TIS. Instead, it turned out to be very useful in connection with introducing desirability aspects into the analysis in section 5.3.2. Due to the huge variety and amount of elements in the TIS, some exploration was needed to determine a satisfying way to structure and analyse these structural components. Key lesson here was, that it is important to not get lost into too much detail and aim for a clear and compact illustration of important (groups of) elements. Finally, I learned that the definition of the development stage and deliberations about an anticipated functional pattern are not only useful for assessing the performance of the TIS, but also to prioritise the blocking and inducement mechanisms for a resulting strategy.

6 Opportunities and barriers for JAGRAN in Malawi

JAGRAN is a Dutch animal science company that developed an innovative low-cost approach using insects to valorise organic waste into sustainable feed ingredients. The company successfully conducted first research and testing in the Netherlands and is now looking for opportunities to introduce the technology in other settings. SAWI identified that the JAGRAN Musca Domestica technology (JMD) may be a good solution for the treatment and valorisation of faecal sludge, a common issue in emerging markets. For this reason, SAWI was assigned to further investigate this opportunity. After a first analysis, Bangladesh and Malawi were selected as locations for further in-depth investigations. In this chapter the opportunities and barriers for the introduction of the JAGRAN Musca Domestica technology (JMD) in Malawi will be explored with the help of an FIS analysis.

6.1 Sources of information

The analysis is based on a range of different sources of information. For preparation previous to the investigation on-location, a meeting with JAGRAN was arranged. Additional to that, a quick scan questionnaire and the report from a feasibility study in Bangladesh provided additional information about the business and the technology and indications about important aspects and relevant actors. The analysis on-location is based on a snowballing method with the existing WASTE network in Malawi as a starting point. WASTE has experience in coordinating and implementing sanitation-related projects in Malawi for more than 10 years and partners include municipalities, social organisations, the private sector as well as research institutes and universities. With the help of this extensive network, other relevant stakeholders such as feed companies could be quickly identified and followed up upon. In particular useful was a related research project aimed at investigating the possibilities for improved sanitation service delivery in Blantyre, taking place parallel to this investigation. Access to relevant policy documents, meetings and focus group discussions with high-rank city officials related to this research provided useful insight into institutional factors that are also relevant to the introduction of the JMD technology. An overview of the stakeholders contributing to this analysis can be found in Appendix 1: Overview of interviewees.

6.2 The JAGRAN Musca Domestica concept

Core of the JAGRAN working principle is the use of house flies as bio converter for organic waste. In a controlled process, eggs are prepared and applied to the organic waste that is placed on trays. After a couple of hours, maggots hatch using the organic input as food source and reducing its volume over a period of three days. After this period, maggots naturally leave the feed source towards the ground in order to pupate. They escape through holes in the bottom of the tray where they can be collected. Later, the pupae can be harvested and processed. In order to achieve reliable quality and output on a large scale, various parameters such as light and temperature have to be carefully controlled during this process. A quality control of the input and the output streams ensures safety and quality of the production process and the final product. Figure 6.1 illustrates this production process.

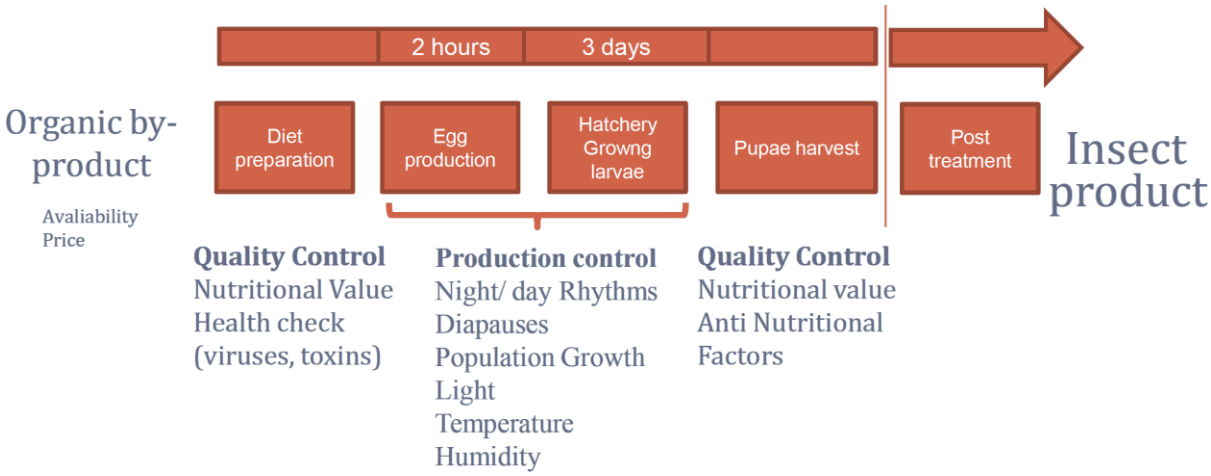

Figure 6.1 Illustration of the JMD process (Jagran, 2012)

The JMD concept works with a variety of different inputs such as municipal organic waste, organic domestic waste, slaughterhouse residue, sludge, chicken litter, swine manure and human manure. Primary output of the JMD concept is pupae. With their high protein content (40-65%) and rich of lysine, methionine, valine and tryptophan, pupae are a good component for animal feed (Jagran, 2012). They can serve as a complement or replacement of other protein sources such as fish meal or soy. Secondary output is the processed waste. Its volume is reduced up to 70% during the process and it may be used as soil improver (compost).

6.3 Country brief Malawi

Malawi is a landlocked country in southeast Africa bordered by Tanzania, Mozambique and Zambia. It has a population of estimated 17 million and is experiencing one of the world's fastest population growth at a rate of currently more than 3% per year (CIA, 2014). With a GNI per capita of just US$320 (2012) it is one of the world's economically least developed countries, but together with other African countries it experienced one of the world's highest growth rates in the last years (Worldbank, 2014). Agriculture is however still of high importance, employing more than 80% of the population (Auswärtiges Amt, 2014). Despite considerable improvements in the overall development of the country in the last decades, Malawi is still facing numerous major problems in the areas of health, education, economy and environment. Health care is still inadequate leading to high maternal and child mortality. Diarrhoea has been one of the major causes of morbidity in under-five children in Malawi caused by poor hygiene and sanitation practises (Chipeta, 2004). Furthermore, there is a high prevalence of diseases such as HIV (more than 10% of the population) and Malaria. Nearly half of the population lives below the poverty line, and malnutrition is a common problem among children. The literacy rate is

Figure 6.2 Location of Malawi on the African continent (Wikimedia, 2014)

improving in recent years but the general education level remains low and especially women do often not get access to adequate education, leading to scarcity of skilled labour and low productivity. Due to limited economic activity, the country is highly dependent on donors that accounted for 36% of the government revenues in the past five years (CIA, 2014). Due to the steep population growth Malawi is one of the most densely populated countries in Africa, putting the environment under severe pressure. Deforestation, land degradation and water pollution due to improper sewage and (industrial) waste disposal are some of the major environmental issues in Malawi (CIA, 2014).

Focus of the research will be the wider Blantyre area situated in South Malawi. Blantyre region is Malawi's biggest urban agglomeration and is referred to as the commercial capital of Malawi. It is a trading and industry hub in the region and has a relatively good infrastructure with well-maintained streets and a railway connection to its neighbouring countries, an international airport and quite reliable water and electricity supply both provided by the nearby Shire River.

Figure 6.3 Position of Blantyre in Malawi (Wikipedia, 2014)

6.4 The FIS analysis

In this section the analysis based on the 6-step FIS approach is presented beginning with defining the TIS, identifying and mapping structural components, analysing the functional patterns and finally deriving key policy issues.

6.4.1 Step 1: Defining the TIS in focus

Central element of this TIS is the JMD technology that has been described above. JMD can however not succeed as a standalone product but it depends on being well-embedded in a supply and value chain as illustrated in Figure 6.4. Accordingly, JAGRAN defines itself as a network company that is concerned with a wider scope than the JMD technology only. The TIS should therefore include relevant stakeholders in the area of waste supply as well as production, sales and marketing of the output materials.

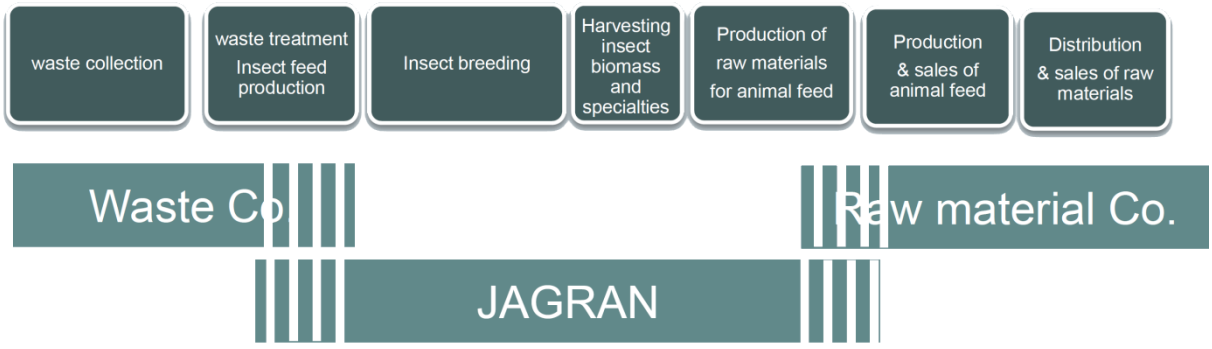

Figure 6.4 JAGRAN supply and value chain (Jagran, 2012)

SAWI is supporting this technology because it offers a potential solution for the sanitation chain and for the re-use of human manure in particular. The TIS should therefore focus on these kinds of inputs. That does not mean that other possible inputs should be excluded from the TIS as they may be considered as transitional or complementary option. An overall strategy is however just satisfactory from a SAWI perspective if it includes the use of sanitation-related inputs such as faecal sludge.

Geographically, the TIS of this analysis is confined to the country of Malawi, with a particular focus on the greater Blantyre area. Blantyre area has been chosen based on strategic and practical considerations. Firstly, it is the country's commercial hub with numerous relevant businesses and services available, offering a good starting point for business activities in Malawi. Secondly, WASTE has a well-established network of partners located in and around Blantyre that allows an efficient and comprehensive investigation with the limited time and budget given.

To conclude, we can define the TIS as "the application of the JMD approach in Malawi under consideration of the required supply and value chain, with a focus on sanitation-related inputs and the area of greater Blantyre". It is important to be aware of the limitations of this analysis that results from this pragmatic compromise between spent resources and breadth/depth of the research.

6.4.2 The sanitation chain of the TIS

From the perspective of JAGRAN, the sanitation chain is just one (optional) part of the JMD approach among various others. For SAWI, establishing a functioning sanitation chain and enhancing its performance is however a key objective when supporting the introduction of an innovation. For this reason, an analysis of this particular part of the TIS is provided in this section. Based on several discussions with the Blantyre City Council, focus group discussions in communities, meetings with representatives of the private sector and interviews with experts, several key issues could be observed:

- The sewerage system is insufficient and not fully functional
- Mid and low density (high income) areas are okay-served with either sewerage or septic tanks that get emptied by the private sector
- Pit latrines provide a satisfactory solution in rural and high density (poor) areas. Full pits are however an increasing problem in high density areas as there is a lack of space to construct new pits, many existing pits cannot be emptied as they are unlined, there is a lack of emptying services and appropriate technology, a lack of financial resources to pay for the emptying and landlords that are not willing/able to take responsibility for toilet maintenance
- Just one of previously five treatment plants in Blantyre is functioning which means that there is a substantial lack of capacity and high transport costs for emptying vacuum trucks etc. leading to illegal dumping

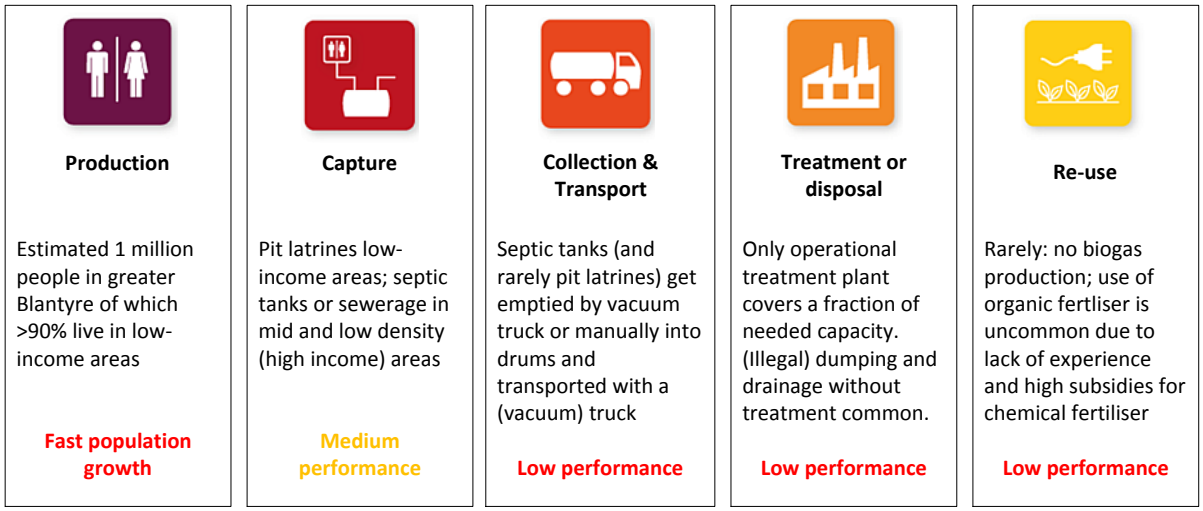

Figure 6.5 Sanitation chain in greater Blantyre

Figure 6.5 gives an overview of the sanitation chain and its current performance with a focus on greater Blantyre revealing substantial potential for development. A satisfactory strategy from a SAWI perspective should aim at addressing at least some of these above-identified key issues when introducing the JMD technology to Malawi. The solution should thereby adhere to the SAWI guidelines.

6.4.3 Step 2: Identifying the structural components

Although JAGRAN itself is not yet present in Malawi, various other components of the above-defined TIS can be already identified. This section gives an overview of these actors, networks and institutions. Presenting all available information about the different components would impede the overall comprehensibility of this report and its key messages. For this reason, further in-depth information is given throughout the analysis in case it becomes necessary. The supply / value chain illustrated in Figure 6.4 gives a good point of orientation to identifying and grouping the structural components of the TIS based on their role(s). Besides, numerous relevant actors, networks and institutions outside of this value chain have been identified and will be described in this section.

The *waste sector* constitutes the supply of input material for the JMD technology. In the context of SAWI sanitation-related elements are of most interest in this analysis. The following relevant actors in this area could be identified

- Individuals and firms constructing toilets/septic tanks
- City of Blantyre operating a limited sewage system and one treatment facility
- Mid-size firms offering septic tank and pit emptying services
- Small firms and entrepreneurs offering manual pit emptying services

On the community level, various networks such as market committees, community networks or church networks for example could be identified. Besides, actors are acting rather individually and formal or informal networks between different actors in the sanitation sector could not be identified. As part of a project coordinated by WASTE and funded by Bill & Melinda Gates foundation, there are however ongoing efforts to address this issue and establish a network and cooperation between the different actors in sanitation. Central element of the institutional components is the *National Sanitation Policy* of Malawi that was published in 2008. Based on this policy the *National Sanitation and Hygiene Promotion Act* as well as according regulations have been established providing the waste sector a legal framework regarding issues such as safe disposal for example. Another important institutional factor is the cost of transport that is determined by various factors such as tax regulations or oil prices on the world market. As for alternative sources of input, relevant actors are the food processing industry and intensive animal husbandry (primarily chicken litter).

The second group of structural components is referred to as *processing* and includes the relevant actors, networks and institutions that are directly connected to the JMD technology. Due to the fact that the JMD technology is not yet established in Malawi, no actors and networks exist in the current TIS accordingly. However, there are already some relevant institutional components:

- Laws, and regulations regarding setting up a business
- Laws, and regulations regarding the operation of a business such as safety or work regulations
- National and international financing and funding opportunities
- Climate and other environmental factors in Malawi

In this context it is also important to point out a missing component: currently, there is no legislation or regulation in Malawi that affects the production of insect protein.

Another set of structural components can be classified as *demand* and covers the output of the JMD technology, larvae and compost. The feed producers, poultry farms and fish farms have been identified as main actors related to the larvae product. For the compost product the fertiliser industry and farmers are relevant actors. Several relevant networks could be identified within this set of actors. Feed producers have a direct/indirect distribution network and/or they are closely connected to one or several fish / poultry farms. Some feed producers also established a network with smallholder farmers by offering training programmes. A variety of institutional components could be identified. As some outputs of the value chain may be exported to other countries it is important to also consider institutional components outside of Malawi:

- Local subsidies for chemical fertiliser (influencing the value/demand of compost)
- Laws and regulations for using insects as animal feed (South Africa, EU, USA)
- Laws and regulations for import of animals that have been fed with feed containing farmed insects (South Africa, EU, USA)
- Laws and regulations regarding different inputs for the production of insect protein (South Africa, EU, USA)
- Cultural acceptance of inputs and insects as animal feed (all relevant markets)
- Level of fish / meat production
- Prices for alternative protein sources (soy, fishmeal)

Again, it is important to point out a missing component: currently, there are no laws and regulations in Malawi regarding the use of insects in animal feed and regarding the use of different inputs (e.g. human manure) for the production of insect protein.

Some structural components can be grouped under the term *knowledge*. That encompasses actors, networks and institutions that are related to the (the development of) knowledge related to the JMD technology. The following relevant local actors have been identified:

- Sanitation-related research at universities
- NGOs with expertise in sanitation
- Private laboratories to analyse input and output streams
- Beekeeping expert providing trainings to smallholder farmers

Several formal and informal sanitation-research related networks between NGOs and universities could be identified. Relevant institutional components are the national research and education policy as well as trends regarding international funding, universities and NGOs. Most remarkable is however the lack of local knowledge-related components in the area of insect breeding. In contrast, on an international level, various knowledge-related components could be identified that may be also relevant to the development of JMD in Malawi:

- JAGRAN and other companies such as Agriprotein (South Africa) or Ynsect (France) with concepts similar to JMD
- Universities and NGOs conducting research related to production of insect protein
- Networks and joint projects related to the production of insect protein such as the recently started €3 million EU project *PROteINSECT*, or the €3 million French project *Desirable* both involving the private sector, NGOs and universities to explore the various aspects of production of insect protein for feed purposes
- Availability of grants for related research by the EU, Dutch government etc.

Figure 6.6 illustrates these above-described structural components of the TIS. Components that are considered as being outside of the TIS but yet expected to be relevant for its development, are positioned accordingly.

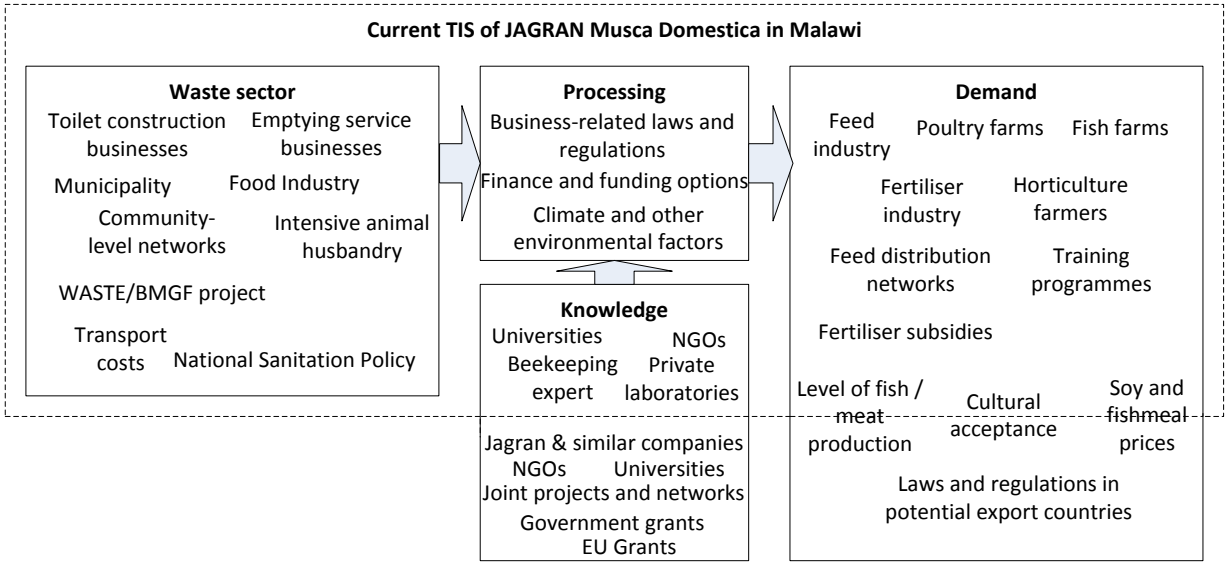

Figure 6.6 Current TIS of JAGRAN Musca Domestica (JMD) in Malawi

Based on this structural analysis, one can already clearly identify possible enactors (i.e. actors that are taking initiative to develop the TIS) and selectors (i.e. actors that are waiting for enactors to take action). The waste sector as well as the demand are clearly selectors in the TIS. JAGRAN has the potential to offer an attractive solution to these groups, but both groups have various alternative solutions available. Also actors in research and related funding are rather in the selector role. That leaves JAGRAN as the (potential) enactor in this TIS. JAGRAN is indeed well-characterised by the enactor description of Suurs (2009) (cp. Table 3.5). Already at this stage, we can therefore conclude, that JAGRAN is most likely the central enacting stakeholder in a strategy for a development of the TIS.

6.4.4 Step 3: Mapping the functional pattern of the TIS

The previous section provided an analysis of the structural components in the current TIS for JAGRAN in Malawi, giving first orientation. This section will focus on mapping the functional patterns of the TIS.

F1: Entrepreneurial activities

Due to the fact that JAGRAN is not yet active in Malawi obviously no entrepreneurial activity directly related to the JMD technology can be observed. However, there are entrepreneurial activities in other parts of the JAGRAN supply and value chain that may contribute to a favourable environment for introducing this innovation.

WES Management is a company operating in Blantyre that recently started its commercial activities in pit emptying. By investing into a new pit emptying technology, the company is able to empty pits considerably faster compared to conventional vacuum trucks and is also able to empty pits where this has not been possible before. This allows lower prices, more capacity and a larger potential market. Other vacuum truck operators already indicated interest to also invest in this technology. This development is very favourable for JAGRAN as it increases the availability of faecal sludge as input.

Also on the demand-side favourable entrepreneurial activities can be observed leading to an increasing demand of quality protein sources. There is an increasing number of businesses in intensive poultry farming leading to an increasing demand of feed accordingly. These good prospects led to the foundation of a new large-scale feed company in 2011, focusing on high quality feed for intensive poultry farming. The company is expanding rapidly, being already number three in the Malawian market, exporting to neighbouring countries such as Mozambique and targeting market leadership by 2015. Also intensive fish farming is taking up in Malawi, currently relying on expensive imported fish meal as protein source that makes up more than 50% of the total production costs. Whereas most of the fish production is located around Lake Malawi, a first large-scale intensive fish farm is about to go in operation in Blantyre area in summer 2014.

Also looking at the lack of entrepreneurial activities is relevant in this context. The absence of similar entrepreneurial activities in Malawi may give JAGRAN a first mover advantage in this market. It may be furthermore advantageous for JAGRAN that there are no or just little entrepreneurial activities related to technologies competing for the input streams such as biogas production.

Besides these entrepreneurial activities within the TIS, also outside of the TIS some relevant entrepreneurial activities are taking place that may influence the introduction of JAGRAN in Malawi. Most importantly, JAGRAN itself engages in entrepreneurial activities by developing and setting up the JMD technology in the Netherlands. Besides, there are other companies similar to JAGRAN that are currently trying to establish a business based on the processing of organic waste with flies. Most notable among these is the start-up company Agriprotein, located geographically close-by in South Africa (Agriprotein, 2014). Besides the obvious threat of emerging competitors this may also have positive effects. Broader entrepreneurial activities in this sector may increase its visibility and acceptance for example with regards to investments or legislation.

F2: Knowledge development

Related knowledge development is very poor in Malawi. Besides a low level of education and research in general, there is no specific knowledge development related to the JMD technology or insect breeding in general. There is however limited research in the area of water and sanitation that may be useful with regards to the use of human faeces as input material. Most notable in this area of research is the interdisciplinary WASHTED department at the Polytechnic University of Malawi in Blantyre. Although it is currently not performing research activities related to the JMD technology, it is very interested in doing so, provided that required resources, funding in particular, are made available. Also WASTE is currently conducting research related to sludge treatment in Malawi. This could be a good entry point to conduct JAGRAN related knowledge development activities in future. Finally, the newly established Malawi University of Science and Technology may provide further capacity for future knowledge development activities.

A considerable amount of knowledge development can be observed outside of the TIS. JAGRAN itself is conducting research activities in the Netherlands with a focus on up-scaling the technology by establishing a mid-scale JAGRAN demonstration plant. In 2013, several related international joint research projects started, investigating the utilisation of flies as bio converter, most notably the €3 million EU project PROteINSECT (Proteinsect, 2014) also conducting research in Ghana and Mali and the €3 million French project Desirable (Ynsect, 2014). As these projects are publicly funded it can be expected that also JAGRAN may benefit from the outcomes of these knowledge development activities involving NGOs, universities and the private sector. Although numerous knowledge development activities can be observed, there are some limitations. Firstly, the knowledge

development related to using faecal sludge as input material is less advanced than the use of other input materials. JAGRAN is currently not engaged into any knowledge development activities in this direction and most of the related research is still in the experimental stage. Secondly, the major focus of research lies on the use of Black Soldier Flies whereas the JMD technology is based on the use of house flies. JAGRAN may therefore not be able to benefit from the research outcomes to its full extent. On the other hand the focus on house flies may lead to a competitive advantage as it provides a (probably more viable) alternative compared to the mainstream research. Overall, the impact of these knowledge development activities outside of the TIS is strongly dependent on to which extent these can be transferred to the Malawian context.

F3: Knowledge diffusion

Currently, the actors of the supply side are quite scattered and not well-organised e.g. in consortiums. For this reason it is expected that knowledge diffusion in this sector may require some additional efforts such as marketing. Within the city of Blantyre, there are however recent efforts to better organise the waste and sanitation services with the help of concessions and service level agreements. This may improve the efficient knowledge diffusion amongst related actors in future. The knowledge diffusion related to the JMD concept itself is difficult to anticipate as it constitutes a genuinely new field of business and technology in Malawi and it is yet unknown which actor constellation may be involved in operating the JMD technology. Generally speaking, a seeing-is-believing mentality can be observed in Malawi. A functioning demonstration facility may be therefore an efficient means to diffuse knowledge about the JMD concept. Also the actors on the demand side are not well-connected or organised. Due to the rather compact size of Malawi there are however just few key players in the feed and fish farming industry that have to be targeted. The feed industry in turn has good existing channels to its end customers offering efficient means for knowledge diffusion through its distributor network and by providing trainings to farmers.

Also knowledge diffusion outside of the TIS may be relevant for JAGRAN. Benefitting from the research activities of other actors depends on how well the research results diffuse among the actors and to what extent they eventually become accessible for JAGRAN. Publicly funded projects such as the aforementioned EU project PROteINSECT do at least have the objective of good knowledge diffusion. It may however be subject to question to what extent this knowledge diffusion is taking place in reality as some actors may have vested interests in protecting some of the gained knowledge.

F4: Guidance of search

There is no guidance of search specifically directed towards JMD and related technologies in Malawi. However, there are relevant developments in the JAGRAN supply / value chain and outside of the TIS.

On the supply-side in Malawi there is an increasing awareness for waste and sanitation-related issues in general. A national sanitation policy has been published in 2008 and as a consequence there are increasing efforts by the national government and municipalities such as Blantyre to implement these policy goals. That leads to an increasing demand for appropriate waste disposal and treatment solutions. Furthermore, there is a clear trend towards public private partnerships as the municipalities lack the (financial) resources to provide appropriate services themselves.

Malawi's poultry and fish industry is increasingly shifting from a prevalent low-input low-output approach towards intensive high-input high-output farming (cp. Figure 6.7). Accordingly the demand for high quality compound feed is increasing. Feed producers and fish farms are already actively looking for alternative protein sources as imported fishmeal is increasingly expensive and inconsistent in quality. They are less guided by a specific technology but are generally interested in a local solution that provides independency from imports, an attractive price and consistent quality.

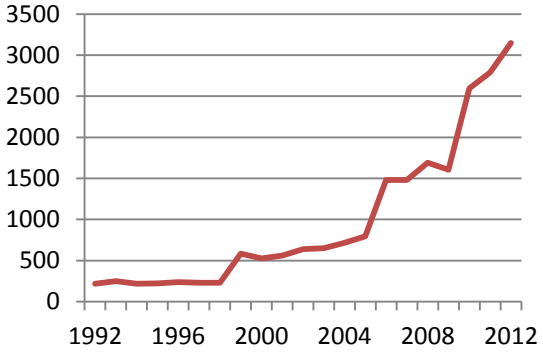

Figure 6.7 Annual output of fish farming in Malawi (t) (FAO, 2014)

Also the worldwide activities outside of the TIS are guided by the increasing price and demand for protein sources that is a result of increasing population, increasing demand for fish and meat and overfishing. Besides, there is an increasing environmental awareness that motivates actors to look for alternatives to fishmeal in particular. The expected market potential is accordingly high.

The technology-related guidance of search goes into different directions. JAGRAN is currently focusing its efforts on large-scale high-tech processing with house flies and organic solid waste as input stream in the Netherlands. By collaborating with WASTE, JAGRAN is also looking into opportunities in other countries and with faecal sludge as input stream. However, this has comparably little priority and accordingly, just little resources are allocated. Most other actors with related activities consider the Black Soldier Fly (BSF) as most promising insect for the conversion of organic waste. Depending on the future performance of the BSF compared to the house fly in the Malawian context this may or may not be an advantage for JAGRAN. Furthermore, there are different directions of search regarding the business-orientation and targeted scale. The JMD approach was developed with initially having the business in mind and aiming at a scalable solution that allows a large-scale application of the technology. Other actors rather focus on the scientific aspects and/or small-scale application only. Also region-wise there are differences with some actors such as Agriprotein or the project PROteINSECT focusing on the African continent, compared to others such as JAGRAN, Ynsect or the project Desirable that are currently focusing on the European market.

F5: Market formation

As JAGRAN is not yet present in Malawi, according markets did not yet form. A good potential for a quick future market formation could however be observed. The Malawian waste sector, representing the supply side, is a largely untapped market. One notable example is the waste of the various markets in the city (>95% organic) that is currently rarely collected but very valuable for re-use. Due to introduction of related policies in sanitation and if people realise the value of organic waste streams it is expected that a market is forming quickly. This could be already observed in the past when feed companies started using waste streams from the industry as input for their products.

On the demand-side, the market for protein sources is well-developed on a national as well as international level. If JAGRAN is able to produce a protein source that is comparable to, and accepted as an alternative to other commodities such as fishmeal or soy, it is expected that an according market forms quickly. For JAGRANs other output stream, compost there is currently just a very little market in Malawi. Most farmers are not accustomed to the use of organic fertiliser such as manure due to lack

of knowledge and high subsidies for chemical fertiliser (up to 97% on the actual price). For this reason it is not expected that any substantial market formation will take place in the near future.

F6: Resource mobilisation

Due to its relatively small size, JAGRAN has just limited financial resources to fund R&D activities. Currently the company is using revenue streams from other existing businesses for this. The availability of resources may however increase considerably, once the company successfully establishes first large-scale operations in the Netherlands planned for 2015. Additionally, due to the earlier-mentioned shift from aid to trade in Dutch development policy (cp. Section 1.2) there may be additional attractive funding options as JAGRAN fits well in the new funding schemes. Related research activities may be also eligible for international funding programmes for example from the EU or foundations such as the Bill&Melinda Gates Foundation. On the other hand, it cannot be expected to acquire substantial local funding for R&D activities in Malawi as the access to capital is difficult and very expensive with a real interest rate that can exceed 15% p.a. These difficulties in acquiring local finance are also very crucial for a later stage of development. In order to gain local investors for a readily developed JMD approach in Malawi, measures such as the provision of soft loans, a high return of investment or little investment requirements should be considered when developing the technology and its accompanying business model.

The availability of appropriate human resources in Malawi is a core issue when it comes to resource mobilisation. There is a very little amount of skilled people in Malawi that may be able to conduct related research activities. The overall educational level at the national universities has been described as comparably low and no programmes related to insect breeding are offered. That means that research activities have to either take place outside of Malawi or skilled people have to be acquired from other countries and local people have to be trained. Also for the operation of a fully-developed JAGRAN plant, people would have to be trained, as it can be expected that there are currently no people with appropriate skills on the Malawian job market.

Technical resources such as construction material etc. are widely available in Malawi for reasonable prices, so that it is expected that no or just a little amount of materials need to be imported for the R&D phase. This may differ for a large-scale operation, though. In this case, Malawi's infrastructure, in particular around Blantyre, allows a rather efficient import from South Africa and overseas. These imports are however subject to comparably high import taxes that can exceed 45%.

F7: Creation of legitimacy / resistance to change

As JAGRAN is not yet introduced to the Malawian market, currently no activities related to this function can be observed in the TIS. Interviewees however indicated issues related to the anticipated future performance of this function.

On the supply-side comparably little issues regarding the creation of legitimacy and resistance to change are expected that may influence the introduction of the technology. Most notably, the efficient large-scale use of faecal sludge requires some changes in the sanitation chain that may be subject to resistance:

- Toilet owners may not anticipate the (financial) advantages of shallower, better-to-empty pits and continue constructing deep pits that take longer to fill up but are not or difficult to empty and provide sludge of less quality for the JMD process

- If pits are emptied, the available work for local masons is decreasing which may cause opposition
- Emptying businesses may be hesitant to adapt new pit emptying technology and engaging in the pit emptying business especially with low-income customers

More resistance is expected with the JMD technology itself. People may perceive the work with insects and human faeces in particular as not desirable and prefer other kinds of employment, leading to difficulties of finding a sufficient amount of entrepreneurs and skilled personnel. Furthermore, some concerns have been raised regarding possible resistance of residents around production facilities due to bad smell or perceived danger (e.g. risk of outbreaks, spread of diseases). Finally, the JMD technology and its processes were initially developed in the Netherlands and may be (partially) incompatible with local work practises.

Interviewees expected that the demand-side is most critical with regards to the performance of this function. The large-scale use of larvae as animal feed is currently largely unknown among legislators, feed producers, livestock farmers and the end customer and legitimacy has to be therefore still created. Furthermore, it was indicated that the use of human faeces in particular may lead to resistance among the stakeholders due to safety concerns and a general culturally-based reluctance of end users to consume food that is somehow connected to the use of human faeces.

6.4.5 Step 4: assessing the functionality of the TIS

In the previous step, the functions of the TIS were assessed individually. In this section, the overall functional configuration will be taken into consideration in order to assess the functionality of the TIS.

First step towards the assessment of the functionality of the TIS is the identification of its current development stage as it is assumed that each development stage requires a different functional configuration. Using the terminology as defined in Hekkert et al. (2011) the TIS in focus can be positioned in a later stage of the pre-development phase (cp. Figure 6.8): There are currently no activities such as a working pilot in Malawi. JAGRAN gathered however some first experience with the JMD technology outside of the TIS (pilot in the Netherlands) bringing it beyond the stage of an idea of a concept paper only. With the existing knowledge and experience, it is expected that JAGRAN would be able to quickly develop a proof-of-concept in the TIS and then develop it further towards a commercial application.

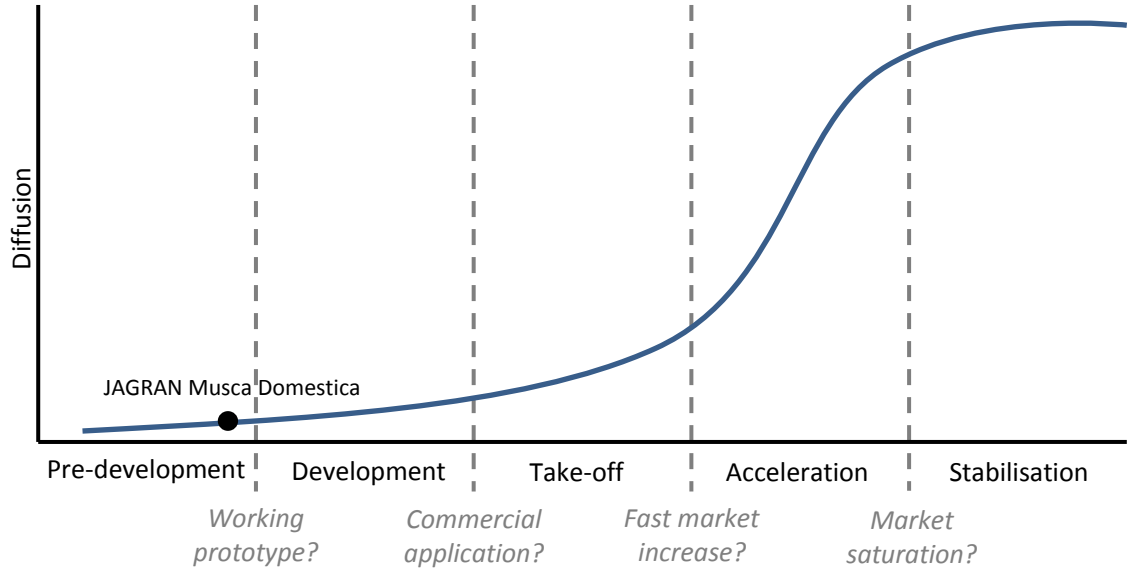

Figure 6.8 Development stage of the TIS (adapted from Hekkert et al. (2011))

As a second step, the most important functions of the current development step have to be identified. It is assumed that the *knowledge development* function plays a central role for the performance of the TIS in this stage of development as it is also suggested by Hekkert et al. (2011): based on existing knowledge and experiences, JAGRAN has to develop its Musca Domestica concept towards a suitable technology for the Malawian context. Also the function *resource mobilisation* is important for the performance of the TIS in this development stage as *knowledge development* activities are dependent on sufficient resources and funding. The *resource mobilisation* is in turn dependent on the *guidance of search* function. Not only JAGRAN itself allocates its resources depending on its guidance of search, but also the availability of external funding is partly dependent on the performance of this function. Furthermore, the guidance of search has a direct influence on the knowledge development activities by determining the scope of research. Hekkert et al. (2011) suggest that also the *knowledge diffusion* function influences the performance of knowledge development. In this case this requires a quite differentiated analysis of this function. On the one hand, JAGRANs knowledge development may benefit from a good knowledge diffusion of related research outcomes. Furthermore, good knowledge diffusion about the larvae product and its benefits is needed among potential customers. On the other hand, JAGRAN may benefit from a competitive advantage if knowledge diffusion about the technology itself remains weak and JAGRAN is able sustain an advance in knowledge compared to its competitors for a longer period. The remaining functions may be of more importance in later development stages. Analysing their current performance may however give valuable insight about the long-term opportunities and challenges towards a large-scale diffusion of the innovation. Figure 6.9 visualises this functional configuration.

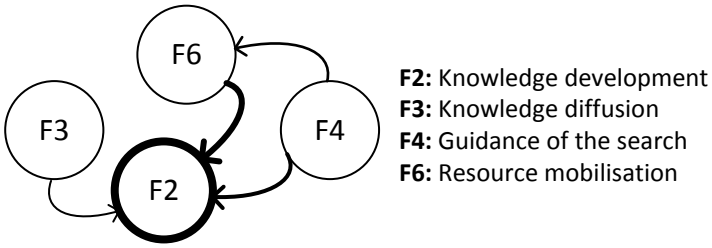

Figure 6.9 Visualisation of the functional pattern

The *guidance of search* around the JMD technology is performing well: trends, expectations and recent developments on the supply and demand-side provide a good enabling environment for the introduction of the JMD technology in Malawi. However, JAGRAN itself has to anticipate these opportunities and shift or widen its own focus towards opportunities outside of the Netherlands and with the use of faecal sludge as input stream. Especially the use of faecal sludge is a topic that is currently not well-aligned among stakeholders. For WASTE, it is inevitable to use faecal sludge as input material as means to improving sanitation. For JAGRAN and other stakeholders, faecal sludge is however just one out of many possible input materials. The performance of the *resource mobilisation* function, in particular the availability of appropriate human resources in Malawi poses a crucial bottleneck for the further development of introducing JAGRAN in Malawi. The knowledge development function, that is central in this development stage, can just perform well if sufficient resources, human resources in particular, can be mobilised. The *knowledge development* activities of the TIS are currently limited to conducting this analysis. Given that above-mentioned bottlenecks can be resolved, there are however good prospects to achieve a good future performance of the knowledge development function: JAGRAN does already have existing experiences in knowledge development in the Netherlands and there are good opportunities for knowledge development activities in Malawi, given that required resources are provided. Due to the developments on the supply-side and a

manageable amount of key actors on the demand-side, there are good prospects regarding *knowledge diffusion*. However, also the ability of JAGRAN to protect parts of its knowledge will define the overall performance of this function in future. Already now, several relevant *entrepreneurial activities* in the supply and demand sector around the JMD technology take place. If designed well, there are good prospects that JMD will be quickly picked up by existing entrepreneurs or new players, leading to a good performance of this function. Once a certain stage of development is reached, the *market formation* function shows good prospects for a quick development. This is especially driven by the fact that fly larvae is a product that may replace existing products (e.g. fishmeal) in a well-established commodity market. This is however strongly dependent on coping well with the issues that have been identified around *creation of legitimacy / resistance to change*.

6.4.6 Step 5: identify inducement and blocking mechanisms

Based on the analysis of the TIS in the previous steps, important blocking and inducement mechanisms are pointed out in this section. Besides, suggestions are given how these blocking and inducement mechanisms could be addressed. This results in a number of strategic options that may be adapted in order to improve the overall performance of the TIS as illustrated in Table 6.1.

Function	Blocking / Inducement mechanism	Possible ways to address mechanism
Guidance of search	Increasing awareness for waste and sanitation-related issues	Offer tailored solutions for these issues
	Increasing demand for affordable protein sources for fish farming	Offer attractive product meeting the demands of these industries
	Increasing awareness for sustainable environmentally friendly livestock feed	Market product as sustainable environmentally friendly alternative
	Mainstream focus on Black Soldier Fly	Identify and promote unique value propositions of using house fly larvae
	Current focus of JAGRAN lies on Dutch/European market	Shift or enhance priorities towards other markets
	Currently no incentive for JAGRAN to specifically focus on faecal sludge as input material	Develop ways to incentivise the use of faecal sludge
Entrepreneurial activities	Increasing entrepreneurial activities on the supply-side	Offer attractive opportunities for entrepreneurs to connect their business to the JMD technology
	No entrepreneurial activities of competing technologies	Act quickly to make use of first mover advantage
	Entrepreneurial activities in other locations (JAGRAN / other companies)	Analyse activities and try to transfer relevant best practises
	Increasing entrepreneurial activities on the demand-side	Analyse and address the needs of these entrepreneurs
Knowledge development	Lack of JAGRAN-related knowledge development	Start KD activities in Malawi Start KD activities related to faeces as input Transfer knowledge from other locations to the Malawian context Acquire knowledge from other parties
	Potential research capacities and related KD activities at local universities and in existing projects	Utilise and connect with existing activities
Resource mobilisation	Limited financial resources of JAGRAN	Wait until revenue of JAGRAN grows due to other business activities
	Funding from EU, NL and other institutions may be available	Research funding opportunities Develop proposals that fit funding schemes
	"Aid to trade" funding trend	Address this trend when identifying and applying for funding opportunities

	Difficult and expensive to acquire capital in Malawi	Reduce required investment costs Develop and offer other financing offers such as soft loans Use external sources of financing
	Lack of appropriate human resources in Malawi	Acquire people from outside of Malawi (e.g. NL) Train people locally Reduce need for skilled personnel
	Importing goods is bureaucratic and expensive	Develop solution that depends mostly on locally available resources
Market formation	Waste and pit emptying sector is underdeveloped	Stimulate market development
	Little market for compost	Awareness building and training farmers for the use of organic fertiliser Use business model that does not depend on selling compost
	Existing commodity market for protein sources	Make product suitable to fit in these existing market channels
Creation of legitimacy / resistance to change	Low cultural acceptance of end users expected if human faeces are used in the food chain	Education and marketing Secrecy Slow transition from other input materials towards faeces
	Possible safety concerns of residents and customers	Extended research and marketing of safety issues
	Possible reluctance to adapt new technologies and practises	Develop incentives Marketing Adjust practises and technologies to fit local expectations and needs
Knowledge diffusion	Actors on supply-side quite scattered	Establish networks between players
	Tangible concepts required (seeing-is-believing mentality)	Create demonstration projects
	Knowledge diffusion activities of related projects	Scout for useful outcomes
	(Too) good knowledge diffusion about technology may decrease competitive advantage	Secrecy Patenting

Table 6.1 Overview of inducement and blocking mechanisms

6.4.7 Step 6: specify key policy issues

In the previous step, numerous blocking and inducement mechanisms and possible ways to address these mechanisms were identified. As it is however neither realistic nor efficient to undertake all of these interventions simultaneously, the most important ones have to be identified and prioritised. The following key issues are drawn up from a WASTE perspective, assuming that WASTE will take an active role in supporting JAGRAN in this innovation process. Based on the considerations about functional patterns in the fourth step, the performance of the knowledge development function is expected to play a central role in the current development stage of the TIS. Furthermore, guidance of search and resource mobilisation have been identified as major influencers of knowledge development. Consequently, the key policy issues focus on addressing blocking and inducement mechanisms of these functions.

Addressing the blocking and inducement mechanisms related to guidance of search can be identified as a crucial starting point. Defining and aligning visions and expectations is essential for the mobilisation of resources and for planning knowledge development activities. Two key blocking mechanisms that have to be addressed are the current focus of JAGRAN on the Dutch market, and the lack of incentives for JAGRAN to consider faecal sludge as an input material. WASTE has to find

ways to convince and commit JAGRAN to follow this, instead of alternative trajectories. Furthermore, WASTE has to (re-)define its own objectives regarding investments and revenues from this partnership and to what extent it allows leniency towards sanitation-related benefits from this partnership. WASTE may for example be perfectly able to support JAGRAN with a solution that also supports other input streams besides faecal sludge. It may however deliberately decide to focus on other partnerships instead that have a stronger impact on improving sanitation. In case an alignment of the guidance of search is achieved, the mobilisation of resources is crucial in order to initiate knowledge development activities. Funds of both JAGRAN and WASTE are currently limited and also businesses in Malawi are hesitant to invest in such an early development stage. As an alternative to waiting for JAGRAN to grow its other business activities and financial capacity in the upcoming years, institutions such as the EU, the Dutch or other governments as well as private foundations may provide viable solutions to support such activities. The current trend of "aid to trade" is a good inducement mechanism that should be addressed when researching and applying for funding opportunities. Besides, the lack of skilled personnel in Malawi, in particular for the research phase, is a crucial blocking mechanism that has to be addressed. In the past, WASTE made good experiences with recruiting students and researchers in the Netherlands that are then conducting research on-location and training local people. WASTE has furthermore access to the platform *Programma Uitzending Managers* that connects senior professionals to volunteering in development-related projects. This may be also a viable solution for JAGRAN. With these two functions performing well, knowledge development activities may be initiated in Malawi. Besides the three key functions that have been highlighted here, also other identified blocking and inducement mechanisms are of importance: issues that are relevant in a later development stage such as coping with acceptance issues for example should be already integral part of the knowledge development activities. Otherwise, there is a considerable risk that a wrong trajectory is chosen and the project comes to halt at a later stage of development.

6.5 Summary and methodological key lessons

The analysis of the TIS around the JMD technology in Malawi provided various insights. The structural analysis identified the different stakeholders and their function in the TIS. With a functional analysis of the TIS it was then possible to determine barriers and opportunities for a short-term as well as a long-term perspective. Overall, it can be concluded that the functional set-up of the TIS provides a promising environment for an introduction of the JMD technology in Malawi. On the other hand, several crucial blocking and inducement mechanisms could be identified. These findings could be prioritised and translated into key policy issues for the further development of a collaboration between WASTE and JAGRAN.

Based on the methodological insights from the first case, it was considerably easier to conduct this FIS analysis as some detours and dead-ends could be avoided. This indicates that already the first case (i.e. first partial design iteration) provided a good amount of insights towards a FIS manual design. Findings from this case were primarily refining and confirming the insights of the first case. Due to the research setting, this case relied much more on informal discussions and meetings which turned out to be good sources of information besides semi-structured interviews. This is a very positive insight as it means that conducting an FIS analysis can be well-combined with other related WASTE activities in an efficient way. Biggest challenge of the analysis was the fact that JAGRAN itself is not yet present in the TIS. This required to distinguish between existing elements and issues and anticipated developments in case JAGRAN enters the TIS. The market scan (pre-feasibility assessment) that was conducted in parallel could benefit from this FIS analysis. The FIS analysis helped to identify important issues that needed further investigation and provided a good orientation for proposing a

strategy and recommending follow-up activities as part of this market scan. Once again, it turned out that determining the development stage and the anticipated functional configuration of the TIS is not only useful for assessing the performance of the TIS but also to select and prioritise the blocking and inducement mechanisms to be addressed. Following this logic, it turned out to be easier and more intuitive to conduct the respective steps four, five and six in an order different to the one indicated. Firstly, blocking and inducement mechanisms were identified (Step 5) based on the mapping of the functional pattern (Step3). Then, the development stage and the anticipated functional configuration of the TIS were defined and a strategy formulated (Step 4 & Step 6).

7 Design of the WASTE FIS manual

This chapter describes the design of a WASTE manual for the FIS approach. It is based on the theoretical insights from literature and the practical experiences that were made during the case work. The chapter points out important aspects that emerged during research and motivates design choices. The manual itself can be found in Appendix 2.

Several key assumptions were made for the overall design of the manual:

- It should be comprehensible and easy to use for WASTE analysts without previous knowledge of the FIS approach
- It should be flexible and allow a wider range of applications
- It should be designed in a way that allows and encourages a further development and adjustment of the approach
- It is used along with the three case descriptions Emergency Sanitation, JAGRAN and the internally created analysis "Pit emptying in Malawi" that are guiding the analyst by example

First part of the manual is an introduction. It provides a brief overview of the FIS approach and its possible fields of application. Furthermore, it aims at setting the right expectations by pointing out the limitations of the FIS approach. These limitations are directly derived from the overall experience and outcomes of the two cases and by comparing them with other kinds of analyses (e.g. feasibility study). It became clear that the FIS can provide guidance and structure during information gathering and the analysis. The responsibility to identify and define key issues however still remains with the analyst. Both cases illustrate, that the outcomes of such a FIS analysis are of overall strategic nature and are rather a complement than a replacement for an in-depth market and feasibility study. The market and feasibility study that was conducted in parallel to the JAGRAN case demonstrated that the FIS analysis can be a very useful complement as it helps to point out important issues and gives support to develop recommendations. As last part of the introduction, the reader is briefly introduced into the scientific background of the FIS approach and is given the opportunity to get a deeper understanding with the help of further reading material provided. These key papers are selected based on the literature review as they were identified as giving a comprehensive and comprehensible overview of the underlying theory and a good starting point for further literature research.

During the entire manual, text boxes encourage the reader to improve and further develop certain aspects of the FIS approach. This is based on the awareness, that due to its limited scope, this research can just be an enabling starting point for the successful use of the FIS within WASTE. Building up more experience about the usage of the FIS is essential to develop the FIS towards a valuable asset for the organisation.

The first step of the analysis, defining the innovation system in focus, remains quite close to the concept in literature that has been described in section 3.3.2. During the case work, the criteria proposed by Bergek et al. (2008) turned out to be adequate in order to define the boundaries of the TIS in focus. As the two cases represent the typical scope of WASTE innovation projects, it is expected that also other existing and future projects can be well-defined based on these criteria. The Emergency Sanitation Sector fit well in the definition of *knowledge field* whereas JAGRAN Musca Domestica was clearly product-focused. Defining a TIS based on the knowledge field of Emergency Sanitation turned out to be more challenging compared to defining the TIS around the JAGRAN Musca Domestica technology. I discovered that a technology review can be very helpful in this case and included it in the manual accordingly. Verbalising the definition of the TIS in a concise sentence was found to be a useful addition. It served as a good reference and guidance during the two cases, for example to decide

what information to include. In the manual, special attention is given to the explanation of the wider definition of *technology*. During the research, this concept often caused confusion among interviewees and WASTE colleagues. Whereas JAGRAN Musca Domestica could be intuitively linked to the term "technology", the connection between Emergency Sanitation as a knowledge field and "technology" was not that clear to many stakeholders.

In contrast to a scientific analysis that demands a more detailed elaboration of methodological aspects, the information in the manual is limited to a brief section about good practises to gather information. Existing WASTE practises turned out to be well-suited to collect the information that is needed to conduct a FIS analysis. It was observed, that the snowball method was already intuitively practised by WASTE. As a useful addition to existing practises, semi-structured interviews are briefly introduced.

The second step of the manual is an addition to the six step approach described in literature. Based on the findings in section 3.3.1, I identified the need to assess the desirability of an innovation. A detailed assessment of the desirability (e.g. with a FIETS assessment) is however out of scope of a FIS analysis and more suitable for a detailed feasibility study. Instead, I analysed the existing sanitation chain of the respective TIS in the two cases and put it into relation with the WASTE guidelines. In both cases, this turned out to be very useful, also beyond raising awareness for desirability only. In the Emergency Sanitation case, this analysis points out the needs for improvement in the different links of the sanitation chain as well as the fact that good solutions need link to each other. In the JAGRAN case, it motivates the focus on faecal sludge as input material for the JAGRAN technology as means to improve the sanitation chain. Furthermore, it increases the understanding about mechanisms behind faecal sludge supply and indicates the potential impact in terms of production volume. Due to these multiple possible outcomes beyond desirability only, this step is described more general as "Review of the sanitation chain of the TIS".

The third step described in the manual, an analysis of the structural elements of the TIS, refers to step two of the approach in literature. The literature review in section 3.3.3 showed that there are a variety of different approaches that may be used to analyse the structural composition of the TIS. During the case work, it turned out to be challenging to select the most suitable approaches and to retain a good compromise between accuracy and not getting lost in too much detail. By means of trial and error, using an adaptation of the "classical modules of an innovation system" (Alkemade, et al., 2007) turned out to deliver the most satisfying result for grouping the elements of the TIS and determining their position and function. The Emergency Sanitation case illustrates, that this approach makes it possible to illustrate a rather complex TIS with many elements and actors in a quite clear and compact way. Also in the JAGRAN case, elements of the value chain could be intuitively adapted to group the elements of the TIS in a clear way. This is needed for a good and efficient functional analysis in the subsequent step. The TIS visualisations of both cases are included in the manual to give inspiration and guide by example. Other concepts such as the diamond were tried, but turned out to be not suitable for these two cases. It is however possible that this may be the case for future innovation projects. The reader is therefore encouraged, to also explore the use of other ways to structure the elements of the TIS. Additional to using the concept of Actors, Networks and Institutions, the concept of enactors and selectors proved to be an insightful analytical exercise to explore potential dynamics of the TIS and to identify potential starting points for developing a strategy. In the Emergency Sanitation case, it was possible to come up with several enactor selector scenarios, of which two formed the base for the two illustrated strategies. In the JAGRAN case, the enactor selector perspective helped to emphasise the need for JAGRAN to take initiative before the technology may be taken up by other actors. The enactor selector concept is simplified in the manual for better understanding, now referring to active

and passive elements in the TIS. The manual reflects these findings and experiences and guides the analyst by means of guiding questions and examples.

The fourth step of the manual (mapping the functional pattern of the TIS) remains quite close to the according third step described in literature. As already mentioned in the fourth chapter, a list of indicators (see Table 3.6, p.20) turned out to be not very useful during the case work. Instead, more general function descriptions, based on experiences during the interviews, are used in the manual. Experience during the case work showed that this step of the analysis is quite intuitive using these function descriptions and with help of the structural analysis in the previous step. As both cases illustrate, especially diverging and contrasting views, opinions and developments are an important aspect of the analysis. This aspect is therefore stressed in the manual. In the Emergency Sanitation case, this was for example achieved by pointing out exceptional developments such as Peepoo. In the JAGRAN case, contrasting JAGRAN-related activities with competitor's activities provided useful insights. Overall, it was possible to assign most of the gathered information to one of the seven functions, indicating that the proposed set of functions adapted from (Hekkert, et al., 2007) was adequate for the analysis of the two cases. The reader of the manual is however encouraged to further improve the function descriptions and consider the use of a different set of functions, if applicable. For example, to anticipate future developments in the functions related research.

The order of the next steps in the manual is changed compared to what can be found in literature. This change is based on the experiences during the case work. While analysing both cases, I noticed that the identification of blocking and inducement mechanisms mainly draws on the mapping of the functional patterns (previous step). The development of the strategy, i.e. selection and prioritisation of mechanisms to address in turn, draws mainly on the deliberations about the current development stage and the functional configuration of the system. For a more straightforward reading experience and analysis, the steps are therefore rearranged accordingly.

In the fifth step of the manual, the blocking and inducement mechanisms are identified and listed along with possible ways to address these mechanisms. It is quite similar to what can be found in literature. By going through the mapped functions it was possible to identify relevant blocking and inducement mechanisms in an intuitive way and also to already come up with possible ways to address these mechanisms. Various examples in literature and the two cases show that presenting these findings in form of a table is a good way to present these findings. While gathering feedback for the two cases, I experienced, that especially this step of the analysis is very enabling for discussions and gathering further input. It allows for discussing, adding or removing mechanisms and ways to address these mechanisms, based on the functional analysis and own knowledge and experience. Different stakeholders often focus on "their own" problems and already have a certain solution in their mind. This step offers a good way to consider all of these different perspectives but also to raise awareness for the whole picture among the stakeholders. This can be for example very useful during a workshop setting. Accordingly, this aspect is described in the manual.

The sixth step of the manual combines the systemic analysis based on functional patterns ("Step 4: Assessing the functionality of the TIS") and the development of a strategy ("Step 6: Specify key policy issues"). The case work revealed that an analysis of the current development stage and its functional pattern is not only useful to assess the functionality of the current TIS. This exercise is also very useful to select and prioritise the blocking and inducement mechanisms that form the strategy. The manual puts a focus on this aspect. The two development stages proposed by Bergek et al. (2007) turned out to be too undifferentiated in this context. Both cases demonstrate that the identified functional configurations and according strategies just cover a comparably small period from concept

towards large-scale diffusion. Comparing the two cases, it can be seen that the anticipated functional configuration differs considerably. The concept adapted from Hekkert et al. (2011) reflects this better and is used in these two cases and the manual accordingly. As already pointed out in section 3.4, currently there is insufficient knowledge about functional configuration of the different development stages. This issue could not be resolved during the case work and requires the analyst to come up with an anticipated functional pattern him-/herself. We have to learn from implemented strategies in future, if the assumptions about suitable functional configurations hold in practise. For this reason, users of the approach are encouraged to share their experiences with regards to functional configurations. This is connected with the hope, that the future use of the FIS approach within WASTE continuously improves its strength as the knowledge about functional configurations increases. Despite this, both cases demonstrate that these anticipated functional patterns can already be very useful. They represent and clarify the underlying assumptions of the analyst and help to explain and motivate the resulting strategy choices towards others. This may not always directly lead to a strategy satisfactory for all relevant stakeholders, but it serves as a good base for discussion and to increase mutual understanding. Furthermore, the Emergency Sanitation case shows that this approach helps to develop several consistent strategies for different project scopes/scenarios based on the same set of assumptions.

8 Reflection and conclusion

This section reflects on the different aspects of the research. Besides conclusions about the practical outcomes of the research that are relevant for WASTE, the overall research process is discussed. Finally, theory-related findings and recommendations for further research are presented.

Applying the FIS approach to two problems of practical relevance to WASTE illustrated that the FIS is indeed a promising approach to guide sanitation-related innovation projects. With some adjustments, it is very intuitive to use and yields useful insight on key issues in the respective innovation setting. The findings remain however on an abstract, strategic level. The approach is therefore no all-in-one solution but just a useful complement to other approaches such as a feasibility study for example. Although it provides guidance for the analyst and makes the process of analysis more transparent and better traceable, it is also no turnkey solution. The quality of an analysis is to a large extent dependent on the expertise of the analyst and its ability to make reasonable judgements. This allows on the other hand a great deal of flexibility and enables the analyst to adjust the approach to the respective needs.

It was possible to translate the findings from literature and the case work into a manual for the use by practitioners. During research, a preliminary version of the manual has already successfully been used by a WASTE associate in order to assess the potential to improve sanitation service delivery with the help of service level agreements in Malawi and to develop strategic recommendations for the next project stage. Resulting feedback gave a first indication that the FIS approach and the according manual may be indeed easy-to-use and a useful addition to the current WASTE/SAWI portfolio.

The work is however not done here. Most notably, there is still little knowledge about the functional configurations in the different development stages of an innovation. Continuously improving the FIS approach based on practical experiences and building up a knowledge base about functional configurations and other aspects is essential in order to improve the strength of the approach and develop it towards a valuable asset for WASTE. Furthermore, the goodness of the strategic recommendations has not yet been proven in practise. The implementation of strategies in future projects will show, if they hold up to their expectations.

The research approach based on the concept of the reflective design was indeed suitable for this research and guided well through the different stages of research. It ensured the practical relevance of the research and helped to meet the expectations of the client WASTE. At the same time, it ensured that the demand for academic relevance and scientifically sound research was met. The case studies proved to be an effective means of research. Due to the given time frame, the number of cases was unfortunately limited to two which restricted the width of the analysis. A bigger variety of different cases may have resulted in a wider range of research outcomes and a wider applicability of the results. The use of several similar cases could have provided insight about the consistency of the FIS approach. Furthermore, the use of quantitative methods may provide additional insights. Finally, there is a certain risk of bias, as the case studies were conducted in a quite elaborate academic way and with an educational background in innovation studies. The future application of the FIS approach within WASTE has to show if an analysis conducted by a WASTE analyst yields similarly valuable outputs. The positive experiences in Malawi (described above) give at least a first indication that this is the case.

Due to the practical design-oriented character of this research, it did not explicitly address the further development of its underlying theoretical concepts. However, various findings were made that can be translated into recommendations for further research and development of the FIS.

So far, the FIS (and also other related approaches) are not explicitly dealing with the desirability of an innovation. This may be acceptable when the FIS is used to assess historical developments. If it is however used to develop strategies for intervention, desirability and sustainability are indispensable guiding principles. In this research, a practical-oriented, context specific approach was chosen to address this issue. Future research may focus on developing more generic approaches to integrate the concepts of desirability and sustainability into the FIS and others.

Both cases illustrate that a functional analysis that deals with foresight can be quite multi-layered. The function descriptions often contain a mix of information that describes the current performance of the function as well as its potential for short-term and long-term development. Future research may investigate how to explicitly deal with these different layers of information and if there are ways to improve the analysis by structuring or separating these different layers of information.

Assessing the performance of a function from an entrepreneurial perspective often requires a quite differentiated view as especially the second case illustrates. Common approaches in literature, such as simply counting the number of events related to a certain function, are insufficient to capture dynamics such as the first-mover advantage for example. Future research should critically assess current approaches for assessing the performance of functions. There is a need for approaches that are more suitable for an analysis from a firm-perspective in particular. Insights from entrepreneurship-related research and other disciplines may provide useful contributions to this.

The analysis of the structural components was a useful exercise in both cases to get a better understanding about what is going on in the TIS and to serve as a base for the functional analysis. It remains however unclear *how* the information between the structural and functional analysis links to each other. Future research may be able to address this issue and for example formalise the use of information from the structural analysis for the functional part in order to make this link more explicit.

Finally, no satisfying answer to the question of sustainability could be given. Deriving strategies from the FIS is of course connected with the hope that interventions resulting from these strategies lead to a more sustainable development of the technology in question. Reality unfortunately shows that, especially in the context of development, innovation projects often come to a halt after an initial set of interventions. An iterative use of the FIS accompanying the different development stages of a TIS may be able to address this problem. More research and practical insight is needed to find ways to ensure and guide such a process.

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Appendix 1: Overview of interviewees

Institution	Function/expertise of the interviewee(s)
JAGRAN B.V.	Director / developer of JAGRAN technology
	Research and Development employee
WASTE	WASTE associate in Malawi with 20 years of local experience in water, sanitation and business development
	Researcher for innovative sludge treatment solutions in Malawi
WES Management	Local sanitation service provider in with more than 10 years of experience in research, implementation, operation and monitoring of sanitation projects
Agrifeeds Ltd.	General Manager / Production director with 10 over years of experience in livestock feed production and processing in Malawi
	Technical Director with experience in plant installation and maintenance in food and feed industry
	Marketing and Sales Director with extensive experience in the feed market of Malawi and Mozambique
Crown Financial Ministries, Malawi	National Director / trainer for farming and financial management with previous experience in large-scale poultry farming
	Manager of inclusive business platforms for subsistence farmers
University of Malawi – The Polytechnic	Director of WASHTED (Department for Water, Sanitation, Health and Appropriate Technology Development)
	Member of Environmental Health department, expert in fecal sludge treatment
AYISE	Executive Director of NGOs that is conducting various community-based projects in Blantyre and other cities
Blantyre City Council	Deputy Chief of Health
	Deputy Chief of Engineering
	Deputy Chief of Finance
	Deputy Chief of Commerce
	Employee of the legal department
	Market supervisor
Chambo Fisheries Blantyre	Owner
Alphamilling / Donna's eggs	Managing director of Malawi's biggest feed and egg producer
Victor Makwanganga	Local farmer using organic fertiliser and innovative farming methods

Appendix 2: WASTE manual for the FIS approach

Guiding sustainable innovations in the sanitation chain

A manual for strategy development with the Functions Approach to Innovation Systems (FIS)

Table of contents

Table of contents 2
Introduction 3
Step 1: Define the innovation system in focus 5
Step 2: Review the sanitation chain of the TIS 8
Step 3: Analyse the structural elements of the TIS 10
Step 4: Mapping the functional pattern of the TIS 13
Step 5: Identifying blocking and inducement mechanisms 15
Step 6: Developing a strategy 16

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Introduction

Introducing innovations is usually a complex process that involves a variety of stakeholders and is connected with a high degree of uncertainty. Being part of an innovation project can be challenging and frustrating. The functions approach to innovation systems (FIS) is a novel approach that can support such innovation projects and make them more successful and efficient. The approach helps to understand the underlying mechanisms and dynamics of a technology and its environment and makes essential strengths and weaknesses visible. This enables us to come up with an effective strategy to address these mechanisms.

What can the FIS be used for?

The FIS can be useful to develop and justify an overall strategy related to the introduction of an innovative sanitation product, concept or service. It helps to define the role of WASTE and other stakeholders in an innovation project and to identify and prioritise strategic options in a structured way. It may be useful to answer questions such as:

- Which next steps should we take to introduce product X to market Y and why?
- Which role should SAWI play in introducing product X to market Y?
- What are the long-term perspectives that justify funding for project X?
- Is company X with product Y a suitable partner for SAWI with a good future prospective?
- What barriers and opportunities does the approach X have in location Y?
- How can we further develop the sector X in location Y?

What is the FIS not?

The FIS is no decision-making tool that delivers a certain prescribed output with given information. It is limited to guiding the analyst during the information gathering process, facilitating an analysis and helps viewing aspects from different perspectives. The responsibility remains with the analyst and individual judgement is required in order to define key issues and priorities. It is furthermore no replacement for a detailed feasibility study but rather a useful complement.

Theoretical background

The FIS approach has its roots in the innovation studies discipline. It is based on extensive research that aims at explaining the processes and dynamics behind the emergence and diffusion of innovations with the help of historical data and by taking a systems perspective. The FIS has been jointly developed by academics from European institutes such as Chalmers University and Utrecht University in order to make these research findings accessible to practitioners. For further reading, the following (academic) articles are recommended:

Bergek, A. et al., 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy, 11 February, 37(2008), pp. 407-429.

Hekkert, M., Negro, S., Heimeriks, G. & Harmsen, R., 2011. Technological Innovation System Analysis - A manual for analysts. Utrecht University - Faculty of Geosciences.

Bergek, A., Hekkert, M. & Jacobsson, S., 2008. Functions in innovation systems: A framework for analysing energy system dynamics and identifying goals for system-building activities by entrepreneurs and policy makers. In: T. Foxon, J. Köhler & C. Oughton, Hrsg. *Innovation for a Low Carbon Economy: Economic, Institutional and Management Approaches.* s.l.:Edward Elgar Publishing.

Help to improve this section!

- Follow up interesting references in the given literature
- Stay updated about new developments in academia
- Add further interesting resources to this list.

The FIS approach in a nutshell

The FIS approach can be divided into six steps that are briefly described below. This manual provides detailed instructions on how to conduct these six steps. Additionally, it gives advice about how to gather the required information and provides suggestions how this approach can be continuously further developed within WASTE.

The FIS approach in a nutshell

Step 1: Define the innovation system in focus

Step 2: Review the sanitation chain of the innovation system

Step 3: Identify relevant technologies, actors, networks and institutions and determine their role in the innovation system

Step 4: Mapping the innovation system based on 7 criteria (functions)

1. Entrepreneurial activities
2. Knowledge development
3. Knowledge diffusion
4. Guidance of search
5. Market formation
6. Resource mobilisation
7. Creation of legitimacy / counteract resistance to change

Step 5: Identify blocking and inducement mechanisms that influence its performance and future development

Step 6: Develop a strategy based on the identified blocking and inducement mechanisms

Although the steps are laid out in a linear fashion, the approach unfolds its full potential only if it is used in an iterative way i.e. to constantly review the steps in light of new information and go back one or several steps if necessary.

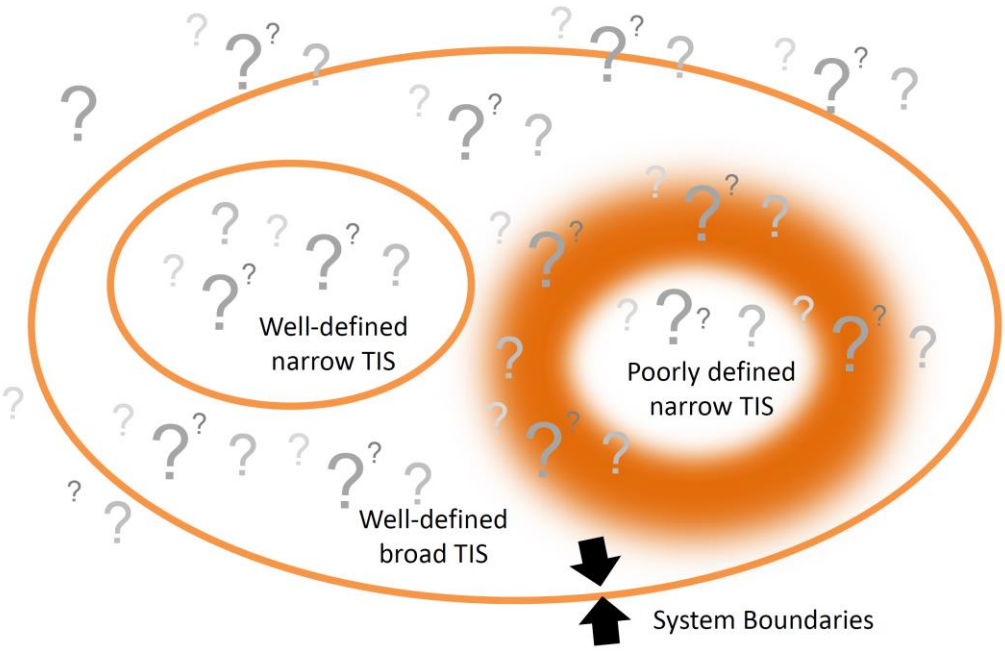
Step 1: Define the innovation system in focus

Before gathering information and starting with the analysis, it is essential to determine the scope and focus of the analysis and answer the question:

"What exactly do we want to analyse and what do we NOT want to analyse?"

Spending some thought on setting the right scope is essential in order to conduct a well-targeted, efficient analysis that meets the needs and expectations of all relevant stakeholders such as WASTE or its clients.

To give an answer to the question above, we use an imaginary analytical concept called "Technological Innovation System" (TIS). Our Innovation System contains all the elements (i.e. actors, networks, institutions, technology) that we determine as relevant for the introduction of our technology in focus. At this stage, it is quite unlikely that we already know all of these elements. In fact, it is quite likely that we discover new elements even in a very late stage of our analysis. We should however have a quite good idea about the *boundaries* of our Innovation System already. The following paragraph provides some ideas to define these boundaries.



What are the boundaries of our TIS?

Central point of our TIS definition is the innovative technology in question. Technology is here used as a very wide term and can refer to:

- a product (e.g. Vacutug)
- a service (e.g. pit emptying)
- an approach (e.g. service level agreements)
- a knowledge field with a product/service/approach yet to be developed (e.g. non-sewer-based sanitation solution)

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We can furthermore specify the boundaries of our Innovation System by determining the "level of aggregation" and "range of applications". Depending on the requirements of the analysis, the *level of aggregation* may be quite narrow and specific (e.g. light-weight urine diversion pit slabs) or rather broad (e.g. raised latrines). The *range of applications* can be defined in terms of a certain market segment (e.g. emergency sanitation) and/or a certain location (e.g. urban areas in Kenya).

Especially when we would like to analyse a whole knowledge / technology field, our TIS definition might still be a bit unspecific at this point. In this case, it may help to review all available products and technologies related to this field and list them for example in a table along with important properties. Based on that, it may be possible to include or exclude certain products or product groups from the TIS.

After these considerations, we should be able to give a brief definition of the TIS that can guide us through the remaining steps of the analysis. For illustration, here are some example definitions if a TIS:

"Safe and sustainable sanitation solutions in emergency situations where pit latrines are not suitable."

"The application of the JAMO approach in Malawi under consideration of the required supply and value chain, with a focus on sanitation-related inputs and the area of greater Blantyre."

"The use of sanitation service level agreements (SSLA) in order to improve the service provision of public toilets in low-income areas of Blantyre."

A brief description of the TIS along with its definition can serve as a good introduction for a written report.

Help to improve this section!

- Add more dimensions that are useful to specify the boundaries of a TIS
- Add your TIS definition to the list of examples

Good practices to gather information

Snowball Method
Relevant stakeholders for interviews or meetings can be efficiently identified by using the snowball method. Ask one or several experts in your existing network during meetings and interviews for other relevant people in the field, ask them again and so forth.

Meetings with WASTE colleagues, companies and other stakeholders
Meetings are integral part of the WASTE way of working and are a good way to gather relevant information for a FIS analysis along the way. Having a good understanding of the FIS approach and the information needed previous to a meeting, helps to ask the right questions and to capture the right bits of information.

Desk research
Also desk research is a method WASTE is well-accustomed with. The FIS approach helps to identify and structure relevant information and to efficiently extract information out of lengthy reports.

Questionnaires
Create new or expand existing questionnaires (e.g. SAWI introduction questionnaire) adding questions that are relevant for an FIS analysis.

Workshops
Use workshops as a platform to share preliminary results and gain new insights. This is especially useful in later stages of the analysis such as Step 5.

Semi-structured in-depth interviews
In-depth interviews may be a useful addition to existing WASTE practices. Several 30min interviews with experts in the field can already provide a huge part of the information needed for an FIS analysis. It is important to create a rough interview guideline, but on the same time leave enough flexibility. Use open questions to encourage the interviewee to share information you did not even think of. It is very useful to record the interviews in order to not miss out information.

Help to improve this section!

- Come up with and document other good ways to gather information

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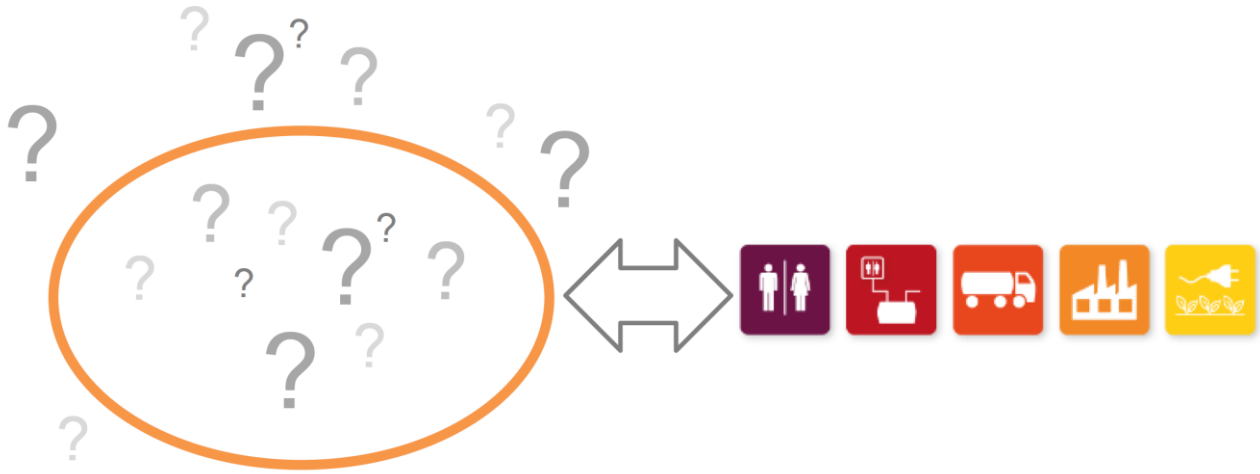
Step 2: Review the sanitation chain of the TIS

The FIS approach does not question the desirability of an innovation. WASTE is however only supporting sustainable and responsible solutions that adhere to the following guidelines:

- The demand or supply can be placed within the sanitation chain
- The solution has to be safe for people and the environment
- The solution is financially sustainable on a local level
- The solution does not disturb and undermine the local private sector

It is important that we consider these guidelines as a guiding principle throughout the whole FIS analysis. We have to ensure that our analysis does not promote solutions that are not desirable and sustainable. A more detailed feasibility study is needed to give a final answer to this question. An analysis of the sanitation chain and putting it in relation to the TIS and technology in question is however a useful exercise to already raise awareness for these issues. The following guiding questions may be useful to conduct such an analysis:

- How does the current sanitation chain look like?
- How do the links of the sanitation chain perform?
- (Where) does the technology in question offer an opportunity to improve the performance within the sanitation chain?
- Are there varieties of the technology in question that are more or less desirable and sustainable than others?



What is the relationship between the TIS and the sanitation chain?

Already at this stage, but also later during the analysis, we may identify some issues that may require us to go back to Step 1 and to adjust the definition of the TIS or to decide that the technology is not suitable to be supported by WASTE after all. Typical scenarios that require adjustments are:

- WASTE just supports the most sustainable variant of the technology in question (e.g. biodegradable additive for mobile toilets)

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- WASTE limits the range of potential markets to places where no adequate solution exists yet
- WASTE just supports technology variants that are related to the sanitation chain (e.g. using faecal sludge as input material for biogas production)

A good starting point to collect and visualise this information is the template below along with a paragraph that explains the relationship between the sanitation chain and the technology in focus.

				
Production	**Capture**	**Collection & Transport**	**Treatment or disposal**	**Re-use**
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Fast population growth	**Medium performance**	**Good performance**	**Low performance**	**Low performance**

Help to improve this section!

- Describe best practises and experiences that help to conduct this step
- Add good examples that help to illustrate this step
- Modify, improve or enhance the template

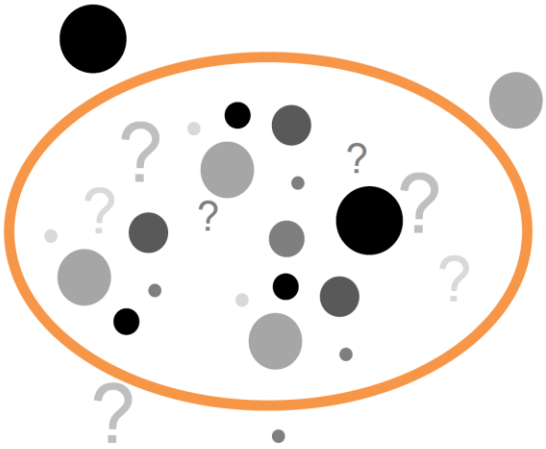
Step 3: Analyse the structural elements of the TIS

In the previous steps we defined our TIS by setting boundaries and defined guiding principles for our analysis. We still know relatively little about what is going on inside of the TIS. In this step we start therefore analysing our TIS by looking at its structural composition. This encompasses all the elements that may be somehow connected to the performance of the innovation system.

In order to capture the whole variety of different elements when acquiring information, it helps to distinguish between four different types of components that are described in the table below. We should thereby not only look for existing elements, but also look for information that indicates the lack of certain components.

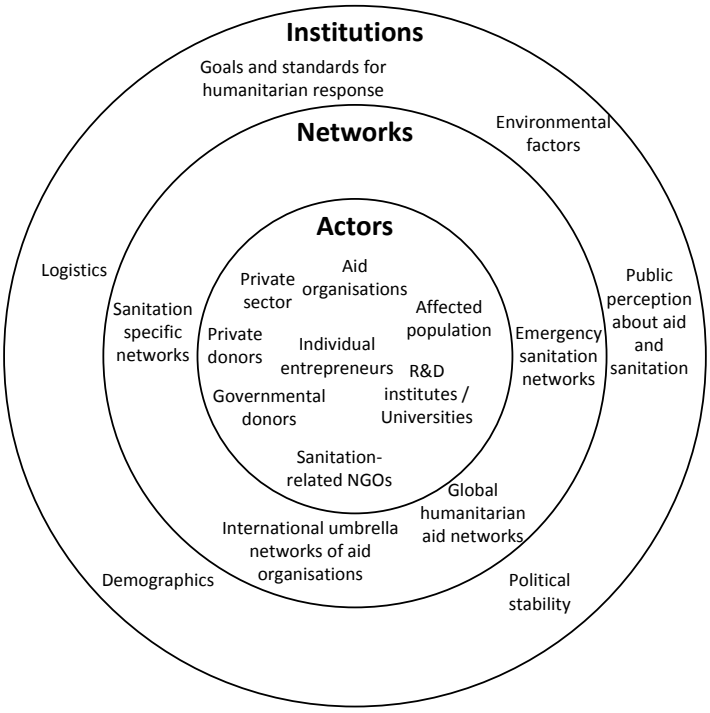
Technology	Existing technical artefacts, products, processes or approaches. This may be already covered in Step 1 of the analysis.
Actors	Individual persons, firms, organisations, universities, (departments of) municipalities.
Networks	Roundtables, consortiums, alliances, interest groups, joint projects, collaborations, informal networks.
Institutions	Laws, regulations, national/global trends, cultural aspects, behaviour.

While conducting this step, it is important but on the same hand challenging to find a good compromise between accuracy and not getting lost in too much detail. Is it for example needed to mention individual companies, is it sufficient to refer to the whole sector or does this sector not have to be mentioned at all? Unfortunately we are not able to provide general guidelines for this as it entirely depends on the individual context. Careful judgement based on the skills and experience of the analyst is needed.



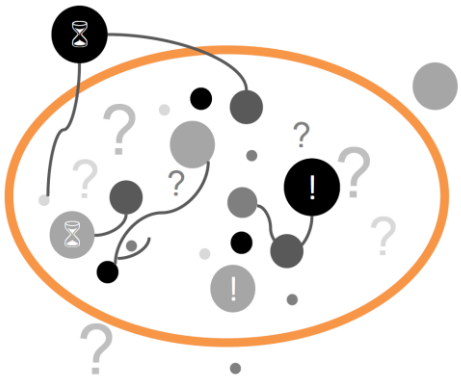
What are the relevant elements in the TIS?

Brainstorming is a good method to create, enhance or verify an overview of the relevant elements of the TIS. Presenting a visualisation as shown below to colleagues, experts or other relevant stakeholders and asking for comments and additions is an intuitive way to gather feedback.



For each of these elements, we try then to answer the following questions:

- What role does this element play in the TIS?
- How important is the element?
- How is the element connected to other elements in the TIS?
- How does the element influence other elements and vice-versa?



What is the role of the elements in the TIS and how do they interact with each other?

Documenting all these answers for all elements individually is likely to become very complex, messy and difficult to analyse in the following steps. We should therefore limit ourselves to the most relevant aspects and group elements that have a similar role within the TIS. There is no one-size-fits-all solution to group the elements of a TIS and there may be different ways to group a TIS depending on the individual requirements and preferences of the analyst. The figures below illustrate how elements may be grouped and visualised. You can notice that some elements are positioned outside of the TIS. They do not fit the TIS definition but are still expected to be relevant.

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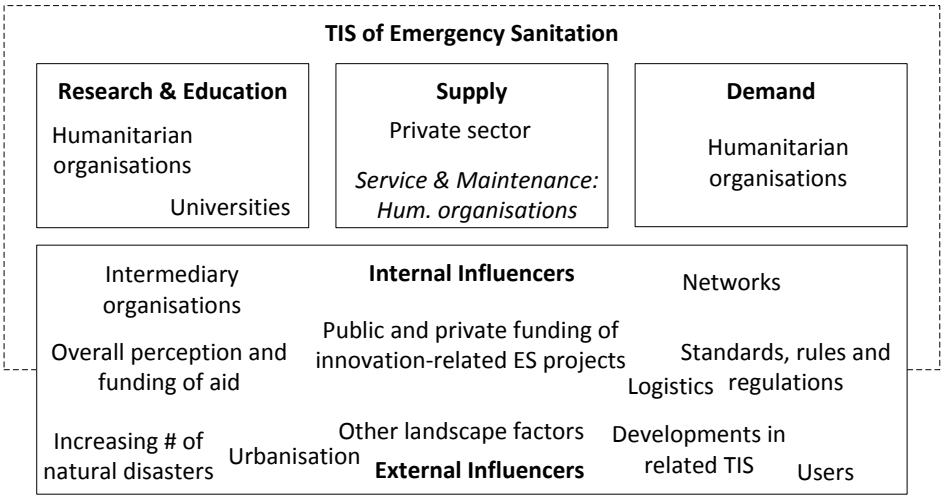

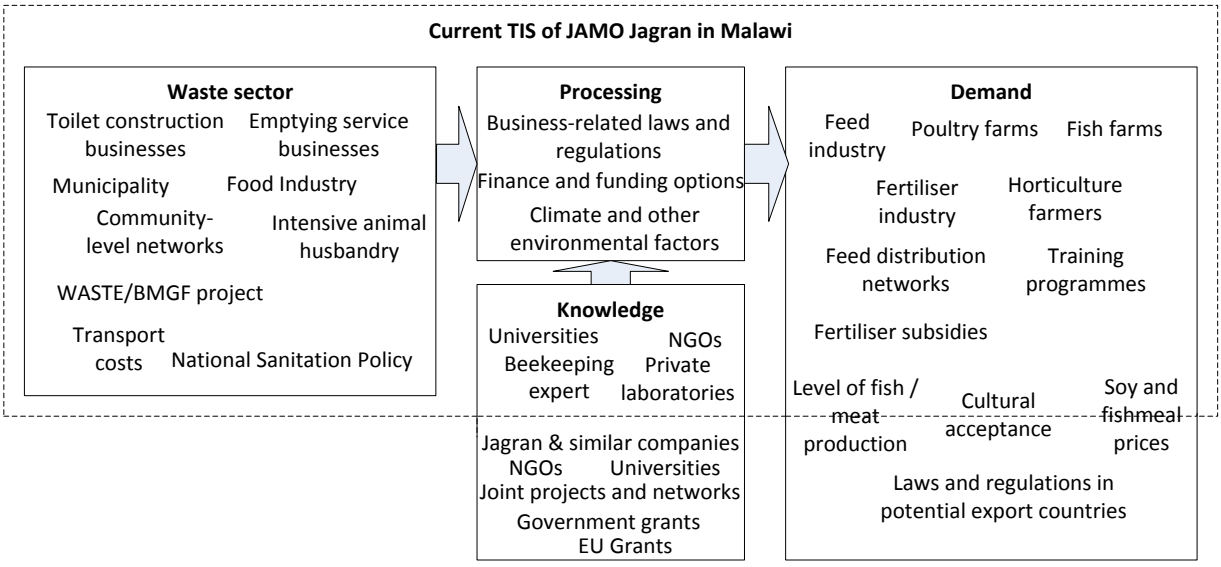

Now that the elements of the TIS are grouped regarding their function, another useful exercise is to determine which actors may have a rather active role in the TIS (i.e. they are likely to initiate changes) and which a rather passive role (i.e. they are likely to wait and react to changes). These deliberations may be a good starting point for the strategy development in the last step. Active actors are typically promoting a single technology whereas passive actors have the choice between several alternative solutions. There may be several possible scenarios.

Help to improve this section!

- Describe best practises and experiences that help to conduct this step
- Add further examples of how elements in a TIS can be grouped
- Other system approaches such as the diamond approach may be a useful to identify and group actors in an alternative way: try it out and share your experiences

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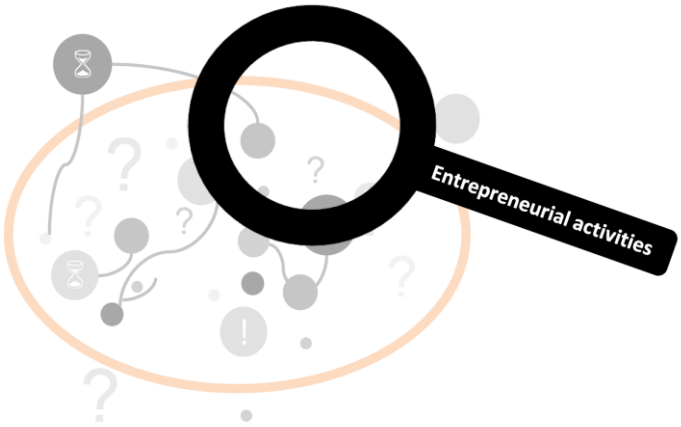
Step 4: Mapping the functional pattern of the TIS

After the last step that provided a more general analysis of the TIS, we are now focusing on seven categories that we refer to as functions. Research showed that these functions are good indicators to describe the processes behind the introduction of an innovation.



How do the different functions in the TIS perform?

Mapping the individual functions is quite intuitive. The table below provides a brief description of the each function along with an indication, what kind of information is relevant for their assessment.

#	Function name	Description
F1	**Entrepreneurial activities**	This function captures the entrepreneurial activities in the TIS. For this function, we need to gather information about start-ups, single entrepreneurs, companies that are investing into new business opportunities, radical new products on the market etc. Besides assessing the extent of entrepreneurial activities it is also important to investigate why certain actors do not perform entrepreneurial activities.
F2	**Knowledge Development**	This function captures the R&D activities related to the technology in focus. Relevant information includes research by universities, NGOs, joint projects and in research departments of companies for example. Besides assessing the extent of knowledge development activities, it is especially interesting to investigate where the focus of research activities diverges between stakeholders and learn more about the underlying reasons behind that.
F3	**Knowledge diffusion**	This function captures the different channels in which the knowledge about the new technology can spread within the TIS. Information about networks, workshops, conferences, marketing channels, experiences with knowledge diffusion in the past etc. is relevant for this function. Also information about elements that may help to diffuse knowledge in future should be considered. Assessing the performance of this function requires a differentiated view. Bad knowledge diffusion may actually lead to a competitive advantage for example and therefore improve the performance of this function.
F4	**Guidance of the search**	This function captures the possible direction(s) the TIS is developing towards. In contrast to information related to the knowledge development function, information related to this function should focus more on a long-term strategic level. This includes information about (perceived) trends, expectations and visions of stakeholders. For the analysis of this function it is especially interesting to investigate where these visions and expectations diverge and learn more about the underlying reasons behind that.

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F5	**Market formation**	This function captures activities that already surpassed the entrepreneurial level e.g. a business that started to become profitable. This includes information about preliminary orders, success cases, price and availability of a product on the market or business models for example.
F6	**Resource mobilisation**	This function captures the availability of resources that are needed for the development and introduction of the technology in focus. Information about the following aspects is needed: ability and willingness of customers to pay; the availability (and costs) of skilled labor, education opportunities, funding, financial services and material. It may be useful to distinguish between resources needed for the development phase and the operational phase in the analysis.
F7	**Creation of legitimacy / counteract resistance to change**	This function captures acceptance issues around the technology in focus. Relevant information includes cultural aspects, decision making processes regarding laws and regulations and conflicts of interest. If there are no experiences regarding this yet, related past experiences (e.g. reports of failed projects) may be a good source of information to anticipate future developments.

Based on this information, the performance of each function can be described in a short paragraph or even more compact in form of a table.

Help to improve this section!

- Describe best practises and experiences that help to conduct this step
- Improve the function descriptions based on own experiences
- Consider using a different set of functions and document your findings here

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Step 5: Identifying blocking and inducement mechanisms

After mapping the functions of the TIS and analysing their current performance we should be able to derive a number of mechanisms that may be blocking or supporting the further development of these functions. We may be also able to already come up with possible ways to address these mechanisms. These findings can be listed in a table such as the one shown below.

Which mechanisms are blocking or inducing the development of the TIS?

Function	Blocking / Inducement mechanism	Possible ways to address mechanism
Guidance of search		
Entrepreneurial activities	Lack of awareness about viable business models	Promote business models among potential entrepreneurs
Knowledge development		
Resource mobilisation	Innovation fits aid to trade scheme	Research suitable funding opportunities
Market formation		
Creation of legitimacy / resistance to change	End users perceive technology as dangerous	Conduct awareness campaign about the safety features
Knowledge diffusion		

This step is very suitable for a brainstorming during a meeting or a workshop for example. After a presentation of the structural and functional analysis of the TIS, even outsiders that have not yet been involved into the analysis may be able to provide useful insights at this stage. This step furthermore allows considering a huge variety of mechanisms and also conflicting opinions as no selections have to be made yet.

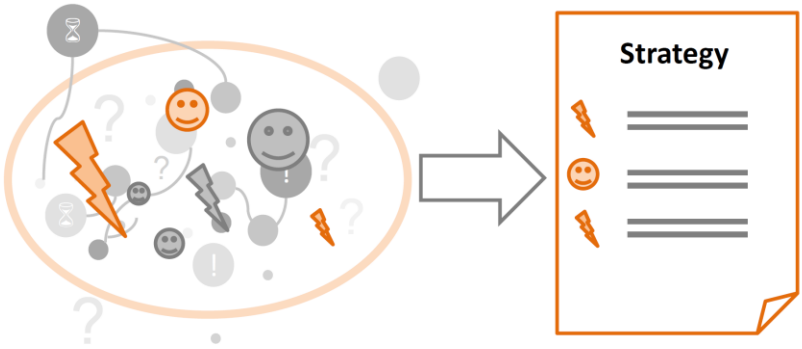
Help to improve this section!

- Describe best practises and experiences (e.g. from workshops)
- Improve the function descriptions based on own experiences
- Consider using a different set of functions and document your findings here

Step 6: Developing a strategy

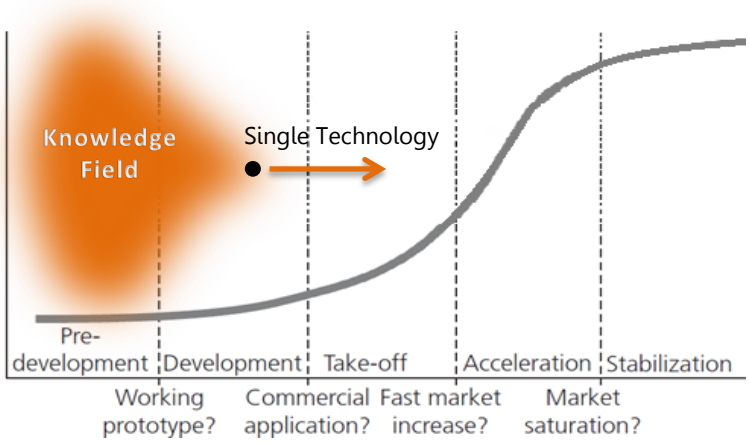
In the previous step, we came up with numerous blocking and inducement mechanisms and possible ways to address these mechanisms. It is obviously inefficient and unrealistic to address all these mechanisms at once. The key to a successful strategy is to select and prioritise the most important interventions under consideration of the given resources and available capacities. We approach this challenge by conducting the following steps

- Determining the current and desired development stage of the TIS that should be covered by the strategy
- Determining the functions that are especially important during this development period and how they influence each other
- Selecting most appropriate interventions based on these considerations and formulate a strategy



Which mechanisms should be selected and prioritised in our strategy?

From an idea to large-scale success, innovations pass different development stages as illustrated below. Based on the analysis we should be able to determine the position of our technology in focus on this graph. A knowledge field may cover a certain range of development stages which can be visualised as shown below. Similarly, we can define the desired development stage that we aim to achieve with our strategy. This aim should be of course realistic and reflect the available capacities and resources. We may for example decide that the aim of our strategy is, to bring our technology from the advanced development phase towards the take-off phase.



Adapted from (Hekkert, et al., 2007)

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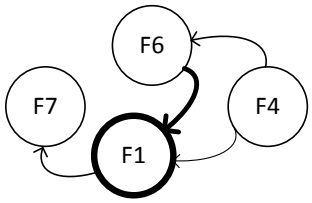
We have now to determine, which functions are especially relevant in order to reach this goal and how they are connected to each other. As the FIS approach is still in an early development stage, we have to rely on our own judgement and experiences for this. Jointly discussing and agreeing on the functional pattern of a TIS is a good way to align assumptions and expectations among several analysts. In future, we may be able to more and more rely on typical functional configurations that have been verified in practise. Taking the example above, we may assume that *entrepreneurial activities (F1)* are especially critical to bring our technology from the development towards the take-off phase. These entrepreneurial activities in turn may be subject to resistance to change (F7). *Resource mobilisation* (F6) may have an important influence on the performance of the entrepreneurial activities and also guidance of search (F4) may have some influence on the *entrepreneurial activities* as well as the *resource mobilisation*. This functional configuration is illustrated below.



Based on these considerations we can now select relevant blocking and inducement mechanisms that form our strategy. These mechanisms can be chosen due to several reasons: easy to address (low hanging fruit), big expected impact, available partners and resource etc. This allows us to not only come up with one, but several strategies suitable for different scenarios (e.g. high and low budget or time-frame).

We may for example propose to start with addressing an inducement mechanism in the resource mobilisation function (e.g. research possible funding options). Next proposed step of our strategy may be addressing a blocking mechanism for entrepreneurial activities (e.g. promote viable business models among entrepreneurs). Finally, we may propose to address a mechanism related to resistance to change (e.g. conduct awareness campaign about safety features).

Help to improve this section!

- Describe best practises and experiences
- Add insights about typical functional configurations from past projects