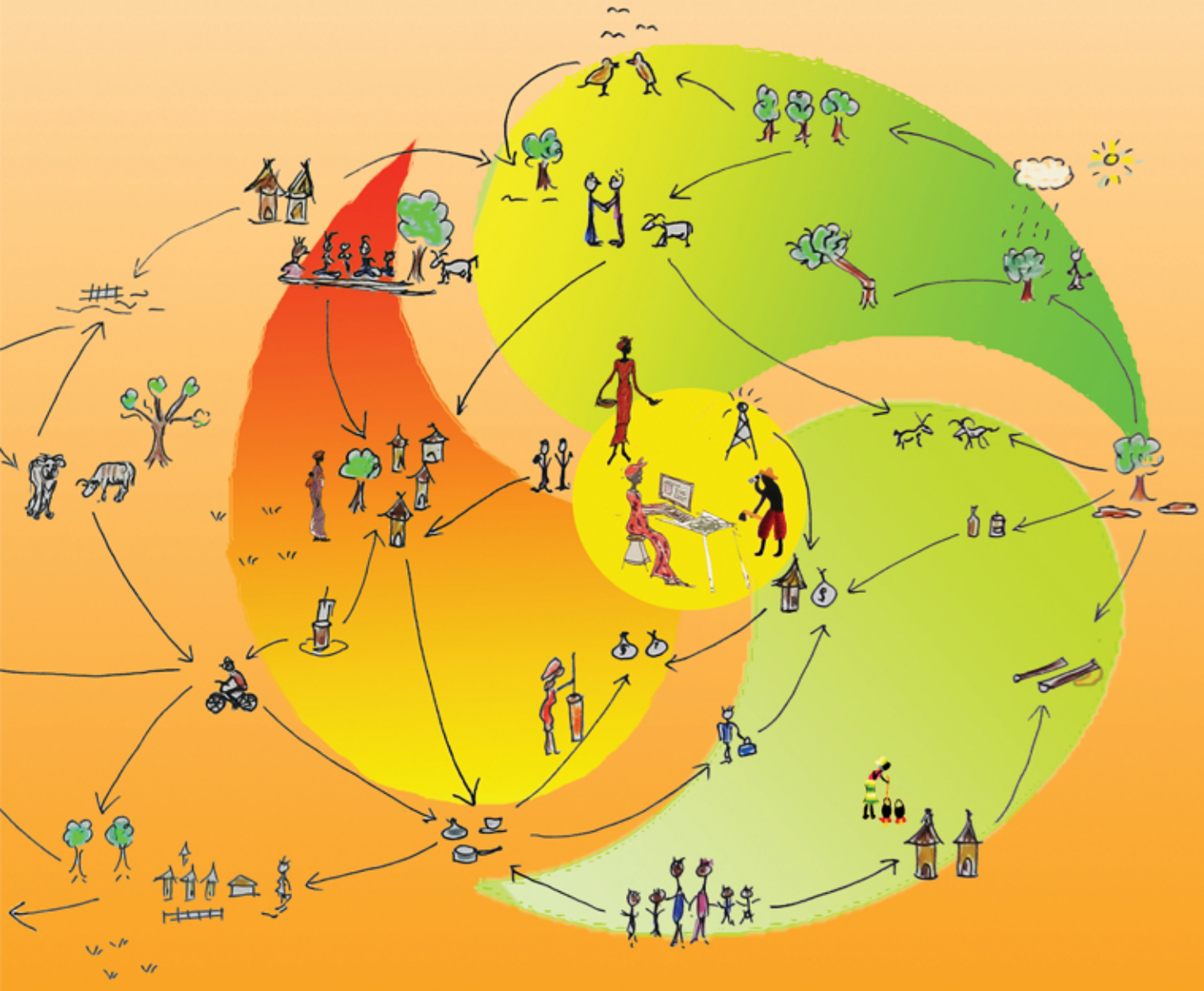
Anna Bon

Intervention or Collaboration?



Rethinking Information and Communication Technologies for Development

Pangea

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Dedicated to Bruno, Paloma and Leeuw

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PREFACE

Over the past decades information system developers and knowledge engineers in ICT projects in wealthy regions of the world have come to realize that technical work can only be successful when situated in a broader organizational context. However, for low-resource environments, where contextual embedding is even more demanding given the complexity of local environments, practical, field-validated methodologies how to *do* information systems engineering are still lacking. To fill this knowledge gap, this book presents a comprehensive set of methodologies that covers the complete lifecycle of information systems engineering, with emphasis on context analysis, needs assessment and use case and requirements analysis.

This book can be used as a practical guide to designing, building and deploying *information and communication technologies for development*. It can be used by students (e.g. in Information Science, Artificial Intelligence, Computer Science) and practitioners (in the development sector or in ICT business). It can also inform policymakers and people interested in international development and technology. It gives a basic but thorough insight in how to develop information systems and services for people in low-resource environments, from a socio-technical, information systems engineering perspective.

This book is the result of extensive field research, conducted by a mixed, multicultural team. The approach is based on design-thinking: it is practical and open-ended. It is inherently inter- and trans-disciplinary, as real world problems cannot be confined within (mono-) disciplinary research boundaries.

Technical development does not go without critical reflection. The reflective technology developer and practitioner has many questions. What are the underlying objectives of the action? Who are the beneficiaries and what are their goals? What are the guiding principles to do this work? This book investigates which assumptions – often tacitly taken for granted – affect the way technologies are implemented in poor, low-resource environments. By bringing together collaborative sociotechnical development with theories of complexity and social networks of innovation, this book offers a reflective approach to information and communication technologies for development.

Collaboration is the central theme of this book – a story of developers and local users working together in the pursuit of a common goal. I am profoundly thankful to all those who supported me and worked with me. I will acknowledge them in chronological order of appearance in this research odyssey, that took many encounters and travels, over a period of ten years.
It all started when, in the summer of 2009, professor Hans Akkermans, founder and director of the Network Institute at VU, stepped into my office and invited me to

help organize a symposium titled the 'Web and Social Development'. The event was a tribute to Tim Berners-Lee, the inventor of the World Wide Web, who was receiving an honorary doctorate from the Computer Science Department at VU. Hans, who was head of this department, asked me to assist him in the organization of this symposium, and also to brainstorm with him about a new, socially oriented ICT research program, based on the same idea as the symposium.

I was working as an international project manager and ICT professional at VU's Centre for International Cooperation (CIS). The influence of technology in the developing world had already grasped my full attention, as I was managing several ICT-related development projects in Ghana, and following the rapid emerging international interest in this theme. Still, in my working environment there was not much interest in the topic. So this remarkable invitation came to me as a surprise.

In the preparation of the symposium and the ensuing research program, my inspiring CIS colleague Chris Reij with his never waning efforts to support African Regreening Initiatives played an important role. Chris presented the story of regreening – local innovation of rural communities in Africa's drylands – at the symposium "The Web and Social Development". The other guests at the symposium were: Sir Tim Berners-Lee, the inventor of the world's largest social and technological knowledge network, and Yacouba Sawadogo, farmer-innovator from rural Burkina Faso, *"The Man who Stopped the Desert"*[1], brilliant yet illiterate, innovator but unconnected, representing millions of unconnected people in the world. This was the setting in which a new research program, the W4RA – the Web Alliance for Regreening in Africa – was born. This was October 20, 2009.

The W4RA (action research) program and alliance have remained active until present day. During weekly meetings in Amsterdam the team members talk about the ongoing research projects. Invited guests and students often join the meetings to discuss ICT4D from various perspectives. The W4RA can be seen as a loosely connected international network of people committed to the cause of supporting and serving the least connected people in the world.

The colleagues in the team are very dear to me. Wendelien Tuyp, team member and buddy from the first day, always cheerful, full of exciting ideas and enthusiasm. Dia Eek, to whom I am deeply thankful for all the kindness and support during all those years: as a guarding angel, Dia shows me how to travel safely, guiding me remotely through insecure regions of the world, making sure everything is more than perfectly arranged. Nana Baah Gyan, whom I first met in 2009, at the Institute for Advanced ICT Studies in Kumasi, Ghana, and who worked closely with us from 2010, and concluded his PhD thesis, titled '*The Web, Speech Technologies and Rural Development in West Africa*'. Francis Dittoh, who investigates and builds data services for African farmers, while maintaining the link between UDS in Tamale and VU Amsterdam. I thank Nana

1 As Yacouba Sawadogo featured in the impressive documentary with the same name, by Marc Dodd, 2009.

and Francis for the collaboration and friendship throughout the years, during courses, workshops and field trips in rural Africa.

In 2011, new colleagues joined the team bringing new creativity and skills: Victor de Boer and Chris van Aart, computer scientists and experts in web science. Victor, talented and creative designer and filmmaker, and Chris, apart from being a gifted app developer and an extreme programmer (I remember how Chris built the tree monitoring application Mr. Jiri in only one afternoon in Ségou) also a business innovator and virtuous horn player. Christophe Guéret brought in many ideas, including Semantic XO and the innovative idea of *"Downscaling the Web"* to make the advantages of the Web more accessible to people in low-resource environments. Thanks, Victor, Chris and Christophe for the interesting and exciting projects we did together.

In its first years, the W4RA group teamed up with the Web Foundation, a charity organization founded by Tim Berners-Lee. This brought new creative minds to the team: Stéphane Boyera, Aman Grewal, and Max Froumentin. We jointly acquired a European research project in the EU-FP7 framework: VOICES, and the Foroba Blon project, that won the International Press Institute Innovation Prize 2011. In these two projects we worked closely with Mary Allen and Etienne Barnard. As a huge joint effort involving many people and organizations, we learned how to successfully design, build and implement voice-based ICT services in rural Mali. We spent many interesting hours discussing the use case and requirements of the envisaged systems. I am thankful to you all for the ideas and experience you brought to me and our team.

During our field research we made many new friends. A very special thank to Amadou Tangara, now country manager of Tree Aid in Mali, for his creativity, cheerfulness and for being a source of innovative ideas. I have learnt so much from you about so many aspects of life in rural Mali. *Merci, grand frère, pour notre travail ensemble, pour la création des idées innovantes, la dédication à la cause du développement rural.*

I am very grateful to Mathieu Ouedraogo, president of Réseau MARP, the innovative, networked non-governmental organization in Burkina Faso that connects and supports farmer organizations all over the country. Mathieu presented a story of innovation and regreening at VU, the day the W4RA was launched. We have worked together ever since, *merci, Mathieu pour ton appui à nos efforts, à la cause des paysans innovateurs, au reverdissement. Je remercie aussi les paysans innovateurs Ousséni Zoromé, Yacouba Sawadogo et Ousséni Kindo, merci infiniment pour votre participation dans nos ateliers, pour tester nos prototypes et évaluer notre travail. Merci,* barka, *en votre langue Mooré. Merci Julien Ouedraogo pour ton appui et pour notre bonne collaboration. Merci aussi Ismael Ouedraogo. Merci Radio La Voix du Paysan, pour plusieurs interviews avec nous, diffusés sur la radio, merci Radio Notre Dame, Radio Savane, Radio Solidarité, et Radio Wend-Panga au Burkina Faso et Radio Sikidolo, Radio Moutian et Radio ORTM Ségou au Mali, pour votre présence et participation active dans plusieurs rencontres et ateliers.*
Grand merci aussi à Seydou Tangara, coordinateur de l'AOPP au Mali et ses collègues pour la hospitalité et la bonne collaboration. Merci aussi, Barke Ousmane Diallo et Souleymane Diarra.

Je remercie Adama Tessougué, journaliste et directeur de Radio Sikidolo. Merci grand frère pour ton appui et pour notre collaboration depuis si longtemps. Je remercie les paysans Zakary Diarra, Naomi Dembelé, Madeleine Dembelé au Mali, qui nous ont aidés a développer nos systèmes, et nous ont encouragés à continuer ce travail. Merci aussi Lamine Togola, Alou Dolo et Renaud Gaudin.

In 2013 the VOICES project ended, and despite its promising results and impact at the level of the *communautés*, the consortium fell apart, as normally happens in donor-funded projects. Our team decided to continue the work, which had only just begun. Based on the idea that long-term sustainability can only be achieved, working together for an extended period, tackling the complexities of the context and the difficulties that arise, I tried to find alternative funding opportunities. We managed to keep the W4RA research alive, working in Mali, Ghana and Burkina Faso since 2014 until present day, with support from internal VU funds, and with funding from the Dutch Ministry of Foreign Affairs, through the Dutch development agency Nuffic and its NFP program. We are very thankful for this support.

In 2015 new enthusiastic young team members joined the core team: André Baart, and Gossa Lô. André gave new life to the idea of Kasadaka (once started by Christophe and Victor) and built a Voice Software Development Kit (VSDK) for which he received the High Potential Innovation Award in 2018. André also rebuilt Foroba Blon version 2.0, which was tested in several occasions by Adama Tessougué at Radio Sikidolo in Konobougou, Mali. André, together with our partners from the local radios, built a meteo voice application in Mooré language, in only one night during a workshop in Gourcy, Burkina Faso, without even speaking a word of Mooré! Gossa spent a few months of research in the Ghanaian rural village of Zanlerigu, together with her colleague and friend Myrthe van der Wekken. Gossa developed DigiVet, a decision-support system for diagnosis of animal diseases in rural Ghana. Currently, Gossa is pioneering in artificial intelligence for development, analyzing African narratives and generating automated stories to understand how context-aware story-telling can be used for knowledge sharing. Thank you André and Gossa for your enthusiasm, for your creativity and great work.

In 2013 the results and experience obtained in our research program led to the design of a new interdisciplinary educational program in ICT4D, targeting master students. This initiative was taken jointly by Stefan Schlobach, Victor de Boer, Christophe Guéret, and myself. We started with only 12 master students Information Science, Computer Science and Artificial Intelligence. The course has now more than 70 students enrolled, in 2019. Thank you Christophe, Stefan, and especially Victor for running with me these courses for seven years now. Thanks also Francis and André for your contribution to this course.

As from 2014, we organized an annual symposium "Perspectives on ICT4D" at VU. We invited speakers from all over the world: Saa Dittoh, Chris Reij, Amadou Tangara, Stéphane Boyera, Mirjam de Bruijn, Maneesha Sudheer (Amrita University India), An-

dré Ran, Chris van Aart, Gayo Diallo (Université de Bordeaux), Cheah Wai Shiang and many others. In 2018 this Symposium was co-located at the prestigious ACM Web Science Conference in Amsterdam. The symposium was part of the ICT4D course, and a channel of dissemination for our work.

In 2015 I started to work with Jaap Gordijn on sustainability models for development, using the e3-value approach. Soon, also Jaap became a dear colleague and friend. It was for me an incredible privilege to work with two excellent researchers: Hans Akkermans and Jaap Gordijn. Jaap encouraged me to formulate the framework that became known as ICT4D 3.0. I am grateful that you have joined me in this exciting field of ICT4D. Thank you Hans and Jaap for your inspiration and support, also in some of the darkest moments of this story.

In 2015 I met Cheah Wai Shiang, postdoctoral researcher from the Universiti Malaysia Sarawak (UNIMAS), who was working in the Netherlands for a period. I invited Cheah and soon he joined the W4RA team. Cheah invited us back, and in 2017 Hans, Jaap and I made a visit to UNIMAS. This led to a new inter-institutional collaboration between VU and UNIMAS, formalized in a Memorandum of Understanding and executed through a faculty-led program in Community Service Education in ICT4D, run by our W4RA team. In 2018 we traveled to Sarawak with eleven VU students Information Science, Computer Science and Artificial Intelligence. I organized the trip and coordinated this 4-week course in Sarawak, entitled "ICT4D in the Field". This was the first field-based socio-technical Information System Engineering ICT4D master course. It became a good validation environment for the robustness and adaptive capacity of the proposed framework ICT4D 3.0. The student team did a great job in only 4 weeks (Allard, Hammeedat, Aron, Judith, Giorgi, Chris, Guusje, Nip, Ludwig, Linh, Tasos, Kuan, Amir, Deva). This was a new step for W4RA: combining our approach in ICT4D with Community Service Learning, in close collaboration with a partner university. I want to thank Cheah for his support to our educational ICT4D project in Sarawak. I also thank the Dean of the Faculty of Computer Science and Information Technology of UNIMAS, Dr. Johari Abdullah and senior lecturer Sze San Nah for their great support to this project.

Although they were not directly involved in this research program, I want to thank the Centre for International Cooperation at VU, where I have worked since 2006 until present day. Thank you Henk van den Heuvel for having supported and helped us to promote the W4RA within VU. Thanks to my supportive colleagues Marise, Rien, Esther, Denyse, Sabina, Colette, Kees, Jorn, and Bert. I am also very grateful to Frans Snijders, director of the VU International Office, for his great and continuous support to our work. I also thank Mojca and Caroline, at the department of Computer Science, for their friendly support.

Doing real world, open-ended, challenge-based research as I describe in this book, has been very rewarding for me. Still it is not easy to manage this type of project in an academic environment. My work and this book have met with great support and en-

thusiasm. However, its collaborative nature trans-disciplinarity setup have also raised criticism from certain members of the academic community. Unfortunately, the spirit of competition and the pursuit of individual achievement –hurdles to collaborative success – are still deeply rooted in contemporary academic culture.

The writing of this book has taken many evenings, weekends, holidays and years of my life. I had to endure not to participate in many family activities, while staring at my screen. This made me wonder if it was really worth the effort, and what is actually the purpose of (my?) life. I want to thank my whole family for their support and patience, their presence and care. My father, Ewoud Bon, my brothers Adri (always open to discuss some geopolitical issue), Arthur (bridging the digital divide in his own creative way), my dear Catarina, Ignácio, Maria and Laura, and also Gerry who read my manuscript and brought up many interesting questions. But first and foremost I am grateful for the patience and care given to me by my love ones, to whom I dedicate this book: Bruno, Paloma and Leeuw.

An important lesson I learned during the past ten years is that achievement is more than the sum of individual efforts, and that there is no better way of learning and innovating than through collaboration, commitment and friendship in a non-formal, non-hierarchical, self-organizing and forward looking team. This is the best way to tackle complex problems and cope with unexpected events. It is how I wish to work. It is the central message of this book.

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ACRONYMS

AOPP Association des organisations professionnelles paysannes

API Application Programming Interface

CAS Complex Adaptive System

CEO Chief executive officer

CERN European Organization for Nuclear Research

DIM Diffusion of Innovation Model

DFID Department for International Development UK

DTMF Dual-Tone Multi-Frequency

(EU) European Union

FB Foroba Blon - voice-based service for citizen journalism in Mali

EU FP-7 Seventh Framework Programme of the European Union

fCFA West African currency (franc CFA)

FM Frequence modulation

FMNR Farmer Managed Natural Regeneration

GO Governmental Organization

GSM Global system for Mobile Communication

HTML hypertext markup language

ICT Information and communication technology

ICTD Information and Communication Technologies and Development

ICT4D Information and Communication Technologies for Development

IP Internet Protocol

IS Information Science

LFA Logical Framework Approach

MARP Méthode action recherche participative

Mbps Megabit per second

MDG Millennium Development Goals

MIS Management Information Systems

MuSCoW Must have, should have, could have, would not have

MVP Millennium Villages Project

NGO Nongovernmental organization

OLPC One Laptop per Child

ORTM Office Radio Télé du Mali

PRA Participatory Rural Appraisal

PTD Participatory Technology Development

PTDA Post-2015 Development Agenda

RCT Random Control Trial

SDG Sustainable Development Goals

SMS Short Message System

SSM Soft Systems Methodology

TTS Text-to-Speech

UCC University of Cape Coast, Ghana

UDS University for Development Studies, Ghana

UML Unified Modeling Language

UN United Nations

UNDP United Nations Development Programme

USAID United Stated Agency for International Development

VOICES Voice-based community-centric mobile services for social development

VU Vrije Universiteit Amsterdam

W4RA Web Alliance for Regreening in Africa

WSIS World Summit on the Information Society

WWW World Wide Web

XO OLPC's $100-laptop

Part I

EXPLORING THE PROBLEM

[in which we explore a central problem of ICT4D: how to make information and communication technologies that serve the needs of the poor and unconnected people]

1

INTERVENTION OR COLLABORATION?

"Being connected", in particular through the Internet and the Web, is universally seen as key to today's information, communication, and knowledge-sharing society. Even more so, "being connected" is also universally seen as a crucial enabler of economic innovation and social development, and this also for poor regions and countries of the world. Still, three to four billion people in the world, mostly in the Global South, have no access to the World Wide Web — the largest global, open and public knowledge–sharing sociotechnical network in human history.

1.1 CONNECTING THE UNCONNECTED (?)

To address this global problem, policies have been launched to "connect the unconnected" and "bridge the digital divide". For example, the United Nations have issued the Sustainable Development Goals (SDGs) for the period 2015–2030, endorsed by the 193 member states of the UN. SDG goal 9c includes the specific target to achieve *"universal and affordable access to the Internet in least developed countries by 2020"*[1]. Very similar policies are echoed and promoted by many different organizations, including big donors in development such as DFID[2], USAID and the World Bank (e.g. [311, 280, 127]). Over the period 2003–2010, the World Bank Group alone invested up to 2.9 billion US dollars in support of the ICT sector, to bridge the digital divide, to the benefit of the poorest countries of the world [126]. In sum, a widespread consensus exists that there is an important role in the world to be played by Information and Communication Technologies for Development (ICT4D).

It is clear that ICTs, and in particular Internet and Web, play a great role in spurring innovation in the wealthy Global North parts of the world, through speeding up knowledge sharing, allowing people to collaborate and share information over large distances and facilitating social interaction and networking. From there, it is a small and natural step to believe that this will also hold for the Global South, as exemplified by the above mentioned policies and attempts to bridge the digital divide. On the other hand, despite all policies, projects, programs, and significant financial efforts to bridge the digital divide and to connect the unconnected, ICT4D efforts have not been very successful in serving the needs of people deemed the least privileged [309, 192, 126, 196, 72, 71, 127, 310].

The present study problematizes the idea of connecting the unconnected and especially the mainstream (i.e. Global North) approach to it. As we will argue, the main-

1 Source: https://sustainabledevelopment.un.org/sdg9, (accessed 31-07-2019)
2 DFID's Digital Strategy 2018-2020 World: https://tinyurl.com/dfid2018digital, (accessed 31-07-2019)

stream approach to ICT4D policy and practice – which can be read as a contemporary framing of conventional, development thinking [238, 239, 234, 90] – involves many (often tacit) assumptions that are widely accepted in the Global North, but do not necessarily hold in the Global South. Alternatives that can work on-the-ground in the Global South are needed and this is a major theme of the present book.

1.2 WHAT DO THE UNCONNECTED WANT?

Concerned about high rates of failure in ICT4D projects, a group of the most influential international development donors and multilateral organizations[3] gathered in New York, in 2012, to reconsider policies and practice and institutionalize lessons learned for ICT4D [323]. A new set of Principles for Digital Development[4], was formulated, featuring *(i) design with the user, (ii) understand the existing eco-system, (iii) design for scale, (iv) build for sustainability (v) be data driven (vi) use open standards, open data, open source, open innovation, (vii) reuse and improve (viii) address privacy and security (ix) be collaborative*. A series of round table conferences in 2015 and 2016 among a broad community of ICT4D practitioners revealed barriers in putting these principles into practice [323]. Many obstacles and barriers were attributed to the international development system itself [323].

Good intentions are good, but not good enough. In looking for alternative approaches to ICT4D practice that can work on–the–ground in the Global South, in our view there is one key question to ask and to research: what do the "unconnected" want? Remarkably, many ICT4D projects, programs and policies do not really ask and (field) investigate this question. In this book we endeavour to show that, if one investigates this question by extensive field research on-the-ground, the idea of connecting the unconnected becomes very different. As a consequence, an operational approach to ICT4D practice was developed that is collaborative, iterative and adaptive. In this book we have attempted to sketch the contours of what a collaborative, iterative, adaptive approach to ICT4D practice will look like, exemplified through many field-research based case examples and studies. This is what we summarize as the ICT4D 3.0 approach.

1.3 HOW THIS BOOK IS STRUCTURED

Information and communication technologies for development, in short *ICT4D* can refer to various different concepts, e.g. (i) to policy and the ensuing efforts by the international community and national governments, to make the advantages of modern ICTs available to the unconnected communities or regions of the world; (ii) to the academic (sub-) disciplines that study the effects and impact of ICTs on developing

3 This includes the World Bank, UNESCO, USAID, DFID, SIDA and UNDP and other development organizations that invest in digitally-supported development projects.

4 See: https://digitalprinciples.org/, (accessed 31-07-2019)

societies and contexts; (iii) to the practice of designing, building and engineering ICT systems and applications in programs and projects in a development context, featuring professionals with a background in ICT science and engineering, e.g. computer science, information science, artificial intelligence, information systems engineering, requirements engineering, human-computer interaction, etc.

This book focuses on the practice and information systems engineering aspects (iii), and takes the position that practice (the operational, field-based micro-level which includes the voices of the "unconnected" people) must link to the macro-level and address and inform policy (i). To do so, ethical considerations and a normative, critical element are included. Based on a combination of extensive field research and experience, this book aims to bridge a gap between theory and practice, linking it to various literatures as theoretical lenses for interpretation and analysis. Its structure consists of three parts, as shown in Figure 1. In Part I, we explore the problem, and investigate current policy and practices of ICT4D in international development. In Part II, we propose an operational framework for ICT4D. Part III consists of reflection, linking practice, theory and critical, value-laden aspects.

1.3.1 *Part I: Exploring the problem*

In Chapter 2, we investigate the assumptions underlying the main contemporary approach to ICT4D policy and practice. My main contribution here is in showing that a "linear", mechanistic notion of *"intervention"* lies at the root of mainstream ICT4D, and more generally, permeates development thinking. Change is thought to be (causally) brought about by an intervention, generally conceptualized as some measure (such as a new technology – say ICT, or Internet – or some other "improvement") that is introduced *from the outside*, and as a result, in a deterministic way, causes social change. This intervention thinking is not just one of the possible conceptions of development: it is a Global North frame or paradigm that has been developed into a global standardized system, such that any development project, program, and policy must conform to this — witness, for example, the rigid requirements and demands widely imposed by donors and funding agencies upon program and project proposals (cf. logical framework, theory of change, detailed rigid planning, fixed budget lines).

There are problems with the received view on development. First, it ignores what is known about the subtle and contextual ("nonlinear") realities and how they ("nonlinearly") influence the processes of sociotechnical innovation and social change. Second, a prime characteristic of intervention thinking is that the people subject to development interventions, the so-called "beneficiaries", are in fact treated as an amorphous mass (variously referred to as the poor, end users, the base of the pyramid, etc.) that undergoes the intervention as passive object, instead of being treated as active subjects in their own right with their own specific interests, contexts, values etc. that consistently must be taken into careful consideration.

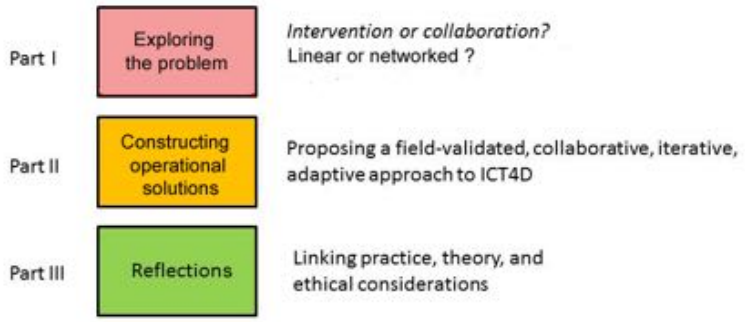

Figure 1: The structure of this book.

Phrased in Global North ICT terms, in today's development thinking the "waterfall model" still reigns supremely. In ICT science as well as practice, this model is now generally considered to be outdated and discredited, but in our view policy makers and practitioners have been slow in adapting to these new realities and insights. This can be summarized in the following questions:

- What are the underlying assumptions and ensuing limitations of the mainstream Global North approach to today's ICT4D projects, programs and policies?
- How can we correct for these limitations of ICT4D policy and practice, so as to come to a new approach that truly incorporates the diverse considerations from the Global South – which may significantly differ from those of the Global North?

Although the intervention model is still the dominant paradigm in development and ICT4D policy and practice, it is not the case that there are no counter-voices or alternatives. Alternative ideas that do justice to changing contexts and realities on–the–ground as well as to the perceptions, values, and interests of the people that directly matter — the supposed beneficiaries — come from many sources, including the Global North. In Chapter 3, we will review a variety of sources for alternative ideas on ICT4D and development actions that avoid the linear, deterministic and mechanistic views that characterize mainstream ICT4D policy and development approaches. Some come from modern ICT methodologies primarily developed in the Global North, including agile approaches and living labs, where the end user has been put in a central place. Others come from critical and participatory development thinking (putting the last first [47], as authors such as Chambers have put it, polemically). As we will argue, there is a diversity of useful critical ideas and insights how to come to better development programs in general and ICT4D projects in particular.

The follow-on key question is how to make these alternative ideas practical and operational in a development context. Or, more specifically phrased as a design problem [324, 92]: what are the requirements for a new approach to ICT4D practice?

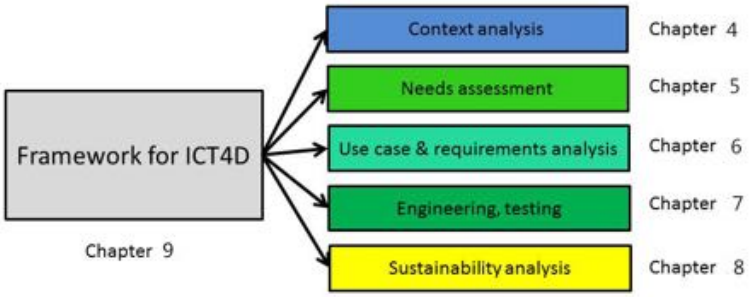

Figure 2: The structure of Part II of this book, presenting an operational approach to develop ICT systems and service in low resource environments.

- Can we design an operational approach to developing ICT systems and services, such that it (i) takes into consideration the complex realities of local context, and (ii) involves the envisaged users in decision-making and sociotechnical development?

1.3.2 *Part II: Constructing operational solutions*

In Part II, an operational method is presented that shows how to develop ICT systems and services for people in low resource environments, in a way that is collaborative, iterative and adaptive. It puts special emphasis on (i) the composition of the interdisciplinary and multicultural team and (ii) the importance of the early upstream stages of ICT systems development. It emphasizes needs analysis in context *'sur le terrain'*/'on the ground' – even before ICT technologies are necessarily being implied. The reason is that inherently sociotechnical systems such as ICT4D services have a heavily *contextualized* nature: the 'known unknown' that requires significant amounts of field-based research.

Then we will discuss, from chapter 4 to 8, a practical approach to ICT4D. We will show how it can be implemented, illustrated by case materials from field research. Each of the chapters 4–8 reflects one of the elements of the lifecycle of Information Systems development as we have extended and adapted it for low-tech, low-resource resource environments. The structure of Part II is shown in Figure 2.

First, Chapter 4 argues for in–depth local context analysis, apart from and even before any ICT or Information System solution is considered. Information System needs and solutions are heavily contextualized. The intervention model with its externally imposed one-size-fits-all ICT solution ideas (such as affordable Internet everywhere) misses the point here. Rigorous context analysis is one of the keys to success, and as we show in Chapter 4, corresponding bottom-up field research (in contrast to western desk research carried out at-a-distance) leads to quite different sets of priorities

and portfolios of ICT solutions than the usual top-down and outside-in mainstream approach.

Next, in Chapter 5 we propose a method for "collaborative goal construction", as part of the needs assessment. The method consists of exploring the problem space, with the local users, making a portfolio of possible solutions and selecting the objectives for the ICT4D project, as formulated by the local users, taking into account the limitations of the local context and the available resources. This method is novel in ICT4D practice. It is part of an intrinsically collaborative decision-making process for ICT4D projects.

In Chapter 6 we present the "structured narrative method". This method enables to capture complex unstructured information and presents it in a structured format. It facilitates communication about requirements in a non-formal way, using narratives and storyboards, while capturing technical system specifications, and represents them through formal models, bridging the worlds between users and technical developers. Moreover, it also covers more than just the narrow technical system. It includes business requirements and information related to the local context – topics not commonly covered in mainstream use case and requirement analysis methods (see e.g. [122, 169, 181, 296]).

Chapter 7 shows how engineering, deploying and evaluating can be done in a non-interventionist, collaborative, adaptive, iterative way that accounts for the specific on-the-ground context, how real innovation works and how local users can influence the process and outcome of an ICT4D project. The pilot demonstrates the importance of extensive sociotechnical field research, of cultural aspects, of collaborating with end-users, of embedding an ICT system in the local context.

Chapter 8 examines the key issue of *sustainability* of ICT solutions in development. It is often (and correctly) complained that prospective development solutions commonly do not survive the pilot phase when the project ends. In Chapter 8, we argue that economic sustainability analysis must and can be done *much earlier* in the systems development cycle, rather than being an ICT4D project afterthought as is the case usually now. To this end, we present a novel and rigorous method, based on the e^3*value* networked business modelling theory and methodology, which is able to do so at an early stage, and we illustrate this approach by practical sustainability studies from our own field research.

This novel — collaborative, iterative, adaptive — practical, field-based approach to ICT4D practice, detailed in Chapters 4–8, that we advocate implies a very different methodological approach regarding how to implement and manage ICT4D actions. The ensuing generalized and configurable methodology is summarized in a framework for ICT4D, conceptualized as an intention-strategy process model in Chapter 9.

1.3.3 *Part III: Reflections*

Presenting an approach to ICT4D practice that is operational only, will not be enough to stir a critical debate about interventionist thinking in ICT4D policy. To do so, reflection is needed, informed by theory and practical action. We do this in Part III of this book.

In Chapter 10, the point is made that ICT4D fundamentally deals with innovation, and has to be treated accordingly, both methodologically and theoretically. Relevant knowledge sharing and diffusion about technologies occurs through social networks, whereby many social and cultural factors come into play in rather unpredictable ways. In contrast, intervention models to development do not take the introduction of ICTs as innovation but as a regular, business-as-usual measure. Intervention models, with their ideas of mechanistic change, thus ignore that innovation and its diffusion is a complex nonlinear dynamic process that works out differently and adaptively in different parts of the world. Hence, an important critique of current ICT4D policies and programs is that they do not adequately take into account the nonlinear, adaptive lessons from innovation diffusion, complex systems and social network theory. The alternative approach to ICT4D practice proposed in this book does.

ICT4D and Development in general undertake to make the world a better place. At least, this is often said or suggested. To take such claims scientifically serious in the Development debate, they must be critically scrutinized like any scientific claim to see whether they are really warranted. We do so in the reflective Chapter 11. So, the general issue is not just about better methodological approaches to ICT4D practice. Beyond this, one has to ask and investigate *whose interests* in the Global South (or North) one is representing, *what goals* one is trying to achieve, where these goals and policies are coming from or *how they are constructed*, and *what core values* are implicated in this. Therefore, in Chapter 11, we argue that collaboration is not just a method, but a core value. It is, or should be, an intrinsic part of an inclusive democratic process of discussion and exchange of views where the stakeholder voices of the Global South are truly included, where one is able to deal with local context and complexity and goals are not imposed from the outside, but emerge from the true Global South stakeholders themselves.

In Chapter 12 we revisit the questions formulated in this first chapter (section 1.3.1) and we reflect on the design question: how an operational approach to developing ICT systems and services should look like, such that it takes into consideration the complex realities of local context, and involves the envisaged users in decision-making and sociotechnical development. This is set in the light of research and practical action which is needed to tackle the problems and serve the needs of the people deemed the least privileged.

1.4 RESEARCH PARADIGMS AND METHODOLOGIES

To position the present research in the landscape of scientific knowledge production, it is important to consider ongoing disputes about the purpose of scientific research, and the relationship between science and society (e.g. [9, 102, 114, 104, 217]). To do so, we consider three intellectual virtues from Antiquity: episteme, techne and phronesis [10].

1.4.1 *Weltanschauung*

In the majority of traditions of scientific discovery, the knowledge focus is on *episteme*, the knowledge category that refers to analytical knowledge and universal truth [10, 105]. Other traditions that include for example technology and medicine are based on *techne*: art, instrumental skill and technical know-how [148, 283]. In some research domains, in particular those concerned with problems in the real world, there is a place for *phronesis* or practical wisdom [10, 104, 4, 326, 95].

In phronesis-based research the purpose is not only to produce new knowledge, but also to solve real world problems [104, 283]. Solving real world problems as a research goal is common in fields such as action research, design science, computer science, information science, engineering and medicine. The researchers seek, not only to understand and explain a phenomenon, but also to improve a situation for a certain context or stakeholder group. Knowing-through-doing, deliberation and practical reasoning are part of the process of knowledge production [246, 321].

Whereas in traditional paradigms of science, the researcher is a detached observer, not allowed to influence research outcomes [279], research based on phronesis has a different *Weltanschauung*. The researcher has a concern for the stakeholders and tries to influence the research outcomes to their benefit. Research goals are defined by deliberation in a communicative space between researchers and users [162]. This takes place in what is called the *agora*, or public debate in Society [162, 3].

1.4.2 *Positioning the present research in the landscape of scientific research*

The present research on ICT4D was conducted in the period 2009 – 2018 in rural regions of Mali, Burkina Faso and northern Ghana – regions representative of "unconnected", low-resource, low-tech development contexts. The research – which aims at desiging and building artefacts to serve local needs in extremely low resource contexts while learning from it and producing actionable knowledge – is problem-driven and purpose-oriented. The research is done in close collaboration with partners, in a broad trans-disciplinary team: academics and non-academics (practitioners, experts, local users). This works as an open system of knowledge generation in a dynamic environment of high uncertainty (in contrast to e.g. controlled lab conditions).

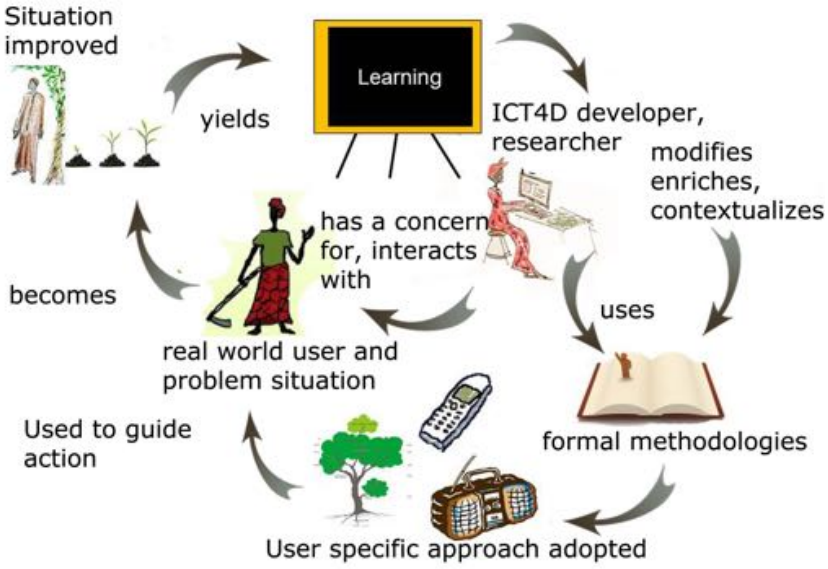

Figure 3: Research approach for ICT4D: producing actionable knowledge and improving a real world situation, while iteratively learning from the process. Adapted after Peter Checkland (2000). Soft Systems Methodology: a 30-year Retrospective. *Systems Research and Behavioral Science*, 17: S11-S58, p.37 [61].

Figure 3 (adapted after Peter Checkland [60, 61]) visualizes the present research and its iterative learning approach. The action researcher is not a neutral observing outsider. She has a concern for and interacts with the users. She modifies, enriches, contextualizes existing methodologies (which are described in Chapter 3), to improve a real-world user problem situation and tries to learn from the process. The notion of 'knowledge in context' is important. Practical reasoning based on 'plausibility' is the central method of analysis, rather than modes of deductive or inductive reasoning, which are used in the natural and social sciences [321]. As the produced knowledge is context-sensitive, it must be iteratively tested and adapted until it is perceived as useful by its users in their specific context [3, 324]. As a consequence, validation of knowledge claims is also done externally, by its users (as in e.g.[29]) rather than by scientific peers [4].

The methodologies and framework brought forward in the present research are based on the idea of scientific knowledge as a socially distributed phenomenon (rather than a purely academic affair), in which knowledge generation is a networked process that takes place in a real world context [246, 162, 214]). Based on this worldview, the present research can be seen as Mode-2 knowledge production [114, 217]. It is associated with action research[5].

5 For an edited overview on action research see e.g. [246, 268, 162, 161].

1.4.3 *Action research*

Action research is an academic endeavor carried out in participative communities of inquiry. Engagement, curiosity and question posing on significant practical issues are key qualities for all involved [246]. Action research is outlined by Peter Reason and Hilary Bradbury as a: *"participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities"* [246].

Proponents of action research and real world research include critical theorists as Jürgen Habermas, Herbert Marcuse, [160, 88] but also participatory action researchers from the Latin American tradition, such as Orlando Fals Borda [93, 94] and Paulo Freire [107, 106]. They consider it the researcher's task not only to gain knowledge about the world around us, but also to change and improve it, to the benefit of its beneficiaries (e.g. [40, 261, 310]). Action research is not widely used in ICT4D research or practice. Apart from our work, there is Oslo group's longstanding work in Health Informatics [36] and a few others [45, 301, 146].

Action research has a purposeful, emancipatory or empowerment character and finds its roots in the social sciences [261]. Central to action research is the concern, not only to explore, describe and explain, as in traditional – both natural and social – sciences, but to facilitate action and help change or make improvements to a real world situation. This is done either indirectly, by e.g. influencing policy, or directly by improving practice [261]. Collaboration with practitioners is organized such that they have a co-research, co-design and co-creation role. Some decolonial authors [92, 32] refer to this methodology as "collective research and action". This perspective of science makes it easier to link science to innovation, and to work in the dynamic complexity of society.

1.4.4 *Mixed methodologies*

As pointed out by Flyvbjerg (2001), phronesis-based research is not organized around specific methods [104]. It is open to methodologies which are best suited to achieve its research goals. In this sense, it also provides a good opportunity to move beyond the methodological debates between positivists and interpretivists about methods of data collection and approaches [283], as it is often noted that standardization constrains the intellectual progress of research and innovation [170, 101, 263]. The present research pragmatically uses mixed methodologies and approaches, borrowed from various research traditions, based on two general requirements.

Firstly, to deal with social contexts in which knowledge, according to ethical human values, is not value-free, an emancipatory, reflexive and critical approach is required, based on deliberation.

Secondly, given the dynamic contexts of high uncertainty and complexity in which this research takes place, methodologies are required which are able to cope with these conditions.

To meet these requirements, approaches and methodologies are borrowed from socio-technical innovation [320], information systems engineering [85], technical action research [324], reflection-in-action [282], soft systems methodology [60, 61], various livelihood approaches [47, 50, 51, 53, 287], and participatory action research [96, 94]. Chapter 3 gives a short overview of a broad range of methodologies and approaches that have inspired this research.

1.4.5 *Mixed methods of data collection*

During the research period 2009 – 2019, a large base of research data was produced, systematically collected and (digitally, safely and redundantly) stored. The raw data include audio recordings of all meetings and interviews, video, field notes, sketches and photos. There is semi-processed information such as field trip reports, use case descriptions, portfolios, prototype descriptions, use case scenarios, conceptual models, technical specifications, source code. There are materials such as short films, articles, blogs, lecture notes, and presentations. All field trips reports, use case descriptions, prototypes, and models are shared and reviewed by the research team. The data consists of 13.611 photos 4268 video fragments and 672 audio files of a total of 200 hours of recordings of full workshops, focus group discussions, interviews and user tests. We did a total of 159 days of fieldwork in a period of 9 years in Mali, Burkina Faso, Ghana and Sarawak, Malaysia. During this fieldwork we did 75 days of co-creation workshops.

Due to the team-based approach during the field sessions, extensive triangulation was done, including data, method and theoretical triangulation [81, 82, 80, 186]. As field research has been carried out in several rural regions, different communities, multiple projects, and different countries, there is furthermore a good amount of regional triangulation, supporting cross-context generalization from diverse case materials.

1.5 NETWORK COMPLEXITY AS A THEORETICAL LENS

A recurring theme in the present research is that innovation is not a linear process with a direct measurable effect caused by the introduction of new technologies. Consequently, it does not make sense to evaluate change in terms of pre-determined goals, for example by means of randomized controlled trial experiments. As an alternative, in this research we put forward the need to theorize on the deeply intertwined social

– overlapping local and global, communal and policy – aspects as well as the technical aspects of ICT4D. This involves design and engineering, but also the associated specific ICT technologies, affordances and struggles over the path-ways of innovation aimed to improvements of people's lives and livelihoods [24]. This idea has led to the complex innovation systems interpretation of ICT4D projects and programs, as discussed in Parts I and III, for which 'nonlinear' (sociotechnical) network complexity theory provides the theoretical lens.

A related theory that explains adoption and proliferation of technologies in complex networked social systems is the Diffusion of Innovations Model (DIM) [264]. Everett Rogers, the intellectual father of the DIM model [263] has discussed diffusion of innovations in the light of complexity theory and has come to the conclusion that DIM and Complex Adaptive Systems can be brought into a co-theoretical model, with a conceptual role for heterogeneous and differentiated social networks [264, 24].

Complexity theory – although not commonly found in ICT4D scientific literature – is proposed as a foundational theory in various studies in the field of development by authors that are differently positioned in the critical social theory debates. For example Ben Ramalingam [244] offers, based on the theory of Complex Adaptive Systems, a book-length critique of the still predominantly linear thinking in development circles. Robert Chambers, in recent work, [50], refers to complexity theory in the setting of sustainable livelihood analysis [286]. Postdevelopment author Arturo Escobar refers to complexity theory at length in his very recent work [92], especially in relation to the struggles of indigenous and Afro-descendant peoples in Latin-American countries. In ICT4D e.g. Braa et al. [34, 36] invoke complexity theory to achieve a better understanding of the 'networks of action' involved in health information systems in developing countries.

In the present research we take networked complexity as a theoretical lens through which we observe the dynamic processes in a given development context (i.c. the case study area in the Sahel) at various scales (the global, national, regional, human scales). Complexity theory underpins the need for an *adaptive* process of socio-technical innovation (to fit the variety of contextual requirements), *collaborative* (to encompass as many viewpoints and knowledge domains (academic/non-academic) as possible on the subject and context), and *iterative* (because of learning cycles). This is discussed in detail in Chapters 1, 4 and 10.

1.6 LITERATURE RELEVANT TO THE SUBJECT

For this research various literatures from inside and outside the field of ICT4D were consulted:

- This book draws from a vast state-of-the-art body of knowledge from the informatics/computer science disciplines [20, 145] regarding Information Systems

engineering [62, 326, 328] (in particular from the subfields of requirements engineering [3, 121, 89, 169], software and service engineering, information systems modelling and specification [97, 30, 324], and – to a lesser extent – knowledge engineering [284, 2] and management and e-business innovation (such as the e^3value methodology) [120, 119]. This contains many state-of-the art insights from ICT/IS engineering science that are of direct relevance to ICT4D (e.g., agile and living lab methodologies [85, 6, 19], advanced and goal-oriented requirements engineering, distributed/networked forms of service and software development, and information modelling advances). This (technical) literature from IS engineering (see Chapter 3) is not widely cited in the (social-science oriented) ICT4D research literature.

- Innovation theory literature is very relevant for ICT4D Information Systems in Digital development [319, 320], especially from the perspective dealing with complex adaptive dynamic systems [263, 264]. A point put forward in this book is the analysis that ICT4D efforts are to be interpreted (and managed) as inherently innovative – even if they comprise mainly established or "old" ICT technologies (i.e., not advanced by western standards). The literature regarding complexity theory gives a theoretical background to better understand and explain why ICT4D projects are inherently complex, why they can easily fail, why simple recipes (such as linear intervention) cannot be expected to work in most cases (also not at the ICT4D policy level), and why alternative engineering and management methods (here dubbed: iterative, adaptive, collaborative) are needed that stand a better chance in dealing with the real-world ICT4D complexities in the field. Therefore, I consulted literature on innovation theory [263, 308], networks of innovation [198] and complexity research e.g. [240, 241, 149, 173, 264, 111, 15].

- Regarding technology innovation and participatory approaches, a variety of sources for alternative ideas exist that avoid the linear, deterministic and mechanistic views. Some come from modern ICT methodologies primarily developed in the Global North [320, 19, 89, 87, 181, 121]. Others come from critical and participatory development thinking (e.g. [47, 254, 43, 93, 95, 251]). These are discussed in Chapter 3.

- For the state-of-the-art of practically oriented ICT4D, regarding user-centered frameworks and approaches, several studies are relevant: [22, 78, 146, 167]. I found only few actionable, field-validated frameworks for engineering ICT4D: e.g. [22, 86, 97, 134]. However, none of these covers all elements of the full lifecycle of information systems engineering in low resource, low tech environments. For example the field of human-computer interaction for development or HCI4D is known for its user-centered methods, and for their special attention to culture, context and usability (e.g. [306, 147, 231, 224, 77]). HCI4D provides interesting

tools and methods that can be used in our overall framework for ICT4D. However, human computer interaction has a narrower scope [307, 83], which is evidently focused on the system's interface (not the operational goal the user wants to achieve with technology), from the perspective of the individual user (not his/her social context). Analysis of e.g. business requirements or mechanisms of collaborative goal construction are out of the scope of HCI4D.

- Regarding ICT4D policy, there is a range of policy documents relevant for ICT4D from major donors (World Bank, USAID and other donors e.g. [311, 280, 127]). Interesting is also a set of critical cases of ICT4D and studies that analyse the conventional methods of project management and evaluation in donor-funded development cooperation projects, concerning policy, evaluation, management information systems, sustainability frameworks and human computer interaction studies [309, 192, 126, 196, 72, 71, 127, 310, 306]. Literature on international development project management provides insight in management methods imposed on practitioners and projects by development donors (e.g.[244, 329, 267]).

- Since *context* is highly relevant for information systems development [3], it is important to understand the context of the research area in which this research was situated: the Sahel in West Africa. There is a large body of interesting literature about local innovation and regreening initiatives e.g. [252, 250, 327, 257, 133, 290].

- Apart from the above resources, a large body of interesting field-based research exists, on the use of ICTs in poor developing regions, for example: [115, 110, 167, 229, 227]. This body of research is focused on the *use* and impact of technologies on local communities, rather than on its design and engineering.

1.7 ISSUES OF EVALUATION AND VALIDATION

As discussed in section 1.4 validation of purpose-oriented, real world research requires evaluation and judgement of the outcomes by its users, in their own context [2, 3, 325, 217].

The results of our research have been evaluated and validated by different user groups in various contexts: (i) end-users and beneficiaries in rural communities in Mali, Burkina Faso and Ghana, (ii) local partners and development experts in these countries, (iii) local businesses and small enterprises, (iv) ICT developers and students who use the framework to build information systems accordingly, (v) the general public, media, the various ICT research communities with an interest in ICT4D, (vi) higher education institutions in the Global South, (vii) donor organizations.

Evaluation of usefulness of the approach and its elements has been done by users and other stakeholders: the farmers and radio stations in Mali, Burkina Faso and Ghana in the period 2011-2018. Part of the use cases that have provided the input

to develop the proposed framework for ICT4D, have been collected and processed during the EU-funded FP-7 research project: VOICES[6] and the Foroba Blon projects, in Mali [26]. Evaluation of the results of this research has been carried out by local stakeholders in West Africa[7]. This is described in Chapters 6 and 7. The continuation of this work until present day[8] shows the local interest and the perceived usefulness of the portfolio of ICT services.

From the perspective of ICT developers, validating the framework consists of using and testing its applicability in a real world setting. The structured narrative format, and the iterative, adaptive approach, which I present in Chapter 6, has been used during the VU ICT4D master course in 2016, 2017 and 2018, in which information services were developed and built according to needs and requirements by farmers in West Africa. It has proven useful and effective. Student project reports are available[9].

A contribution to the validation of the proposed method for sustainability analysis, described in Chapter 8 was done in a master research project, June 2017[10] with field data collected from local business partner: Radio Sikidolo, in Konobougou, Mali.

In 2018 and 2019 the complete framework ICT4D 3.0 has been employed in rural Sarawak, Malaysia, during the master project "ICT4D in the Field". In this educational project, a mixed team of 20 students from VU and UNIMAS[11] have jointly developed technologies to support rural communities in Sarawak, Malaysia. These field-based student projects[12] cover the full lifecycle of software development, according to the approach and framework ICT4D 3.0. The outcomes of the student projects were considered successful from a technical and organizational point of view, and they were also tested, and evaluated by the users in a small local community (kampung) in Sarawak.

This ICT4D research has attracted the attention of various higher education institutions in the South, who are interested in including this approach to ICT4D in their educational curricula, and with whom we are currently partnering: the University of Malaysia Sarawak[13], Amrita University in India[14], the University for Development Studies in Ghana[15].

6 See: http://mvoices.eu, (accessed 31-07-2019)
7 see https://tinyurl.com/validation-VOICES and **??**
8 This collaborative work on e.g. Foroba Blon has continued after donor-funded projects were finished and shows the intrinsic interest in this work for all participants: farmer organization AOPP, Radio Sikidolo in Mali and others.
9 See e.g. https://w4ra.org/student-projects-ict4d-course-vu-2018/
10 Thesis by Jamila Daoudi, see https://tinyurl.com/sust-e3-Mali, (accessed 31-07-2019)
11 The Faculty of Computer Science and Information Technology of the University of Malaysia Sarawak.
12 See the student projects: https://tinyurl.com/BannaTree, https://tinyurl.com/GulaApp and https://tinyurl.com/EDUCOMX
13 See: https://tinyurl.com/vu-unimas-project, (accessed 31-07-2019)
14 See: https://tinyurl.com/VU-amrita-project, (accessed 31-07-2019)
15 See: https://tinyurl.com/VU-UDS-project, (accessed 31-07-2019)

The research that has led to ICT4D 3.0, is the work of many people: researchers, students, practitioners, local partners and users in various countries (Mali, Burkina Faso, Ghana, Malaysia), collaborating in a trans-disciplinary and multicultural team.

1.8 ICT4D 3.0

This book describes a framework, methodology and approach – dubbed ICT4D 3.0 – how to develop ICT systems and services for people in low resource environments. This framework is summarized in Chapter 9. It is a practical, operational framework that covers the full lifecycle of information systems engineering and involves a process of collaborative decision-making with local users. It also includes special elements of context analysis, local knowledge elicitation and sustainability analysis.

The framework transcends the practitioners level – to avoid being used as a technocratic solution – and adds a normative, critical element, concerning the value-laden aspects of ICT4D that address aspects of poverty, livelihoods, interests and power. It also connects practice and theory by its conceptualization of ICT4D as a dynamic process of developing, adapting, diffusing technologies in a complex, real world. Innovation and complexity theories help explain the effectiveness of a networked approach in coping with complexity and situated-ness.

User-centered, adaptive design is not new in ICT, innovation and information systems engineering. However, bringing it into practice in complex low resource environments is not easy or trivial and requires special skills, knowledge and organization. The proposed framework, supported by a large body of real world cases, is elaborated in depth over an extended period, exemplified by field evidence from various countries. The framework is easy to use by practitioners and students. It can be reconfigured and adapted to become useful in any context.

This book proposes an alternative to the linear transfer of technology that characterizes "mainstream" ICT4D projects, that are designed and organized according to conventional development policies (see e.g. [35, 238, 239, 234]).

2

THE LOGIC OF INTERVENTIONISM

In this chapter we take a closer look at the logic of the mainstream approach to ICT4D in policy and practice. We interrogate it through a set of critical questions. How are goals and objectives for ICT4D defined? What is the role of end-users and beneficiaries of ICT4D? How are project evaluations done? Which project management methods are used? How does ICT4D cope with the complexity of real-world contexts? To answer these questions, we will discuss and assess several cases of high-profile ICT4D and development projects from the literature. Generally, one can say that a strongly simplifying concept of "intervention" lies at the heart of current development and ICT4D thinking.

2.1 ICT4D POLICY AND PRACTICE

Intervention – a deliberate action to bring about a particular change and achieve a preferred state of affairs – is a central concept in international development [238]. Interventions are designed according to international development policies. They aim to improve a situation or solve a real-world problem that affects people in the developing world. Interventions are financed through national and international public and private funds[1]. The word 'intervention' is derived from the latin verb 'intervenire', which means 'to come in between', 'to interfere'.

Interventions in international development are organized through a hierarchical structure of stakeholders, each with different responsibilities. Stakeholders include policy-makers, funding agencies, project executers/implementors, and evaluators (e.g. [163, 329, 8]).

Policy-makers are responsible for development of policies at national and international levels. Donor agencies formulate programs according to these policies and fund the actions. Execution and management of development projects is done by practitioners from implementing agencies, who have been selected and contracted, through an official procurement procedure. Evaluation of results is done by evaluators or researchers[2].

ICT4D, as part of international development programs, is designed and formulated according to policies at the level of international organizations, including the United Nations and the World Bank. ICT4D interventions are organized according to a step-

1 E.g. the Rockefeller Foundation and the Bill & Melinda Gates Foundation, the "Nederlandse Postcodeloterij" and many others.

2 See e.g. USAID: ADS Chapter 201 – Program Cycle Operational Policy, Partial Revision Date: https://www.usaid.gov/sites/default/files/documents/1870/201.pdf, (accessed 31-07-2019)

wise project lifecycle, using a "linear" project management approach, which consists of various phases. First there is identification of needs, in line with development policy and strategies. Second is the phase of design and preparation of project plan by experts. This is followed by a phase of selection of an (independent) implementing agency. Next is the phase of project implementation. Evaluation and reporting of results and impacts to the donor are the final stages of the lifecycle.

Goals and objectives for ICT4D interventions are formulated in line with international development policies, to achieve concrete results, outcomes and impacts. The results and outcomes of ICT4D interventions are evaluated against baselines.

The beneficiaries, the subjects of development interventions (often mentioned as the "poor and marginalized" e.g. [140, 274, 136]) do not play an active role in the project life cycle of ICT4D. They are considered passive recipients who do not participate in agenda-setting or decision-making. They are not included in the formulation of goals and objectives or in project design.

The term "intervention" is widely used in development circles, in policy, practice and research (e.g. [222, 58, 165]). Yet, the term evokes strong associations to medical curation, laboratory experimentation, and to imposing political or military power. This has deep implications for thinking about development. Intervention, therefore, is not an innocent concept. It is a fundamental concept that needs to be unpacked. In the following sections, I will discuss some examples of ICT4D interventions.

2.2 ICT4D AS LINEAR INNOVATION

ICT4D generally consists of a transfer of technologies, information or knowledge to developing regions. How this is done in a high-profile ICT4D project, that aims to improve primary education in developing countries, is discussed in this section. For this project, a group of scientists and developers in the Global North have invented and designed a technological concept, assuming that this will solve a problem in the developing world [126]. The technology is funded by national governments and development donors and rolled out at large-scale in developing countries.

2.2.1 *OLPC: laptops to transform primary education*

In January 2005, at the Economic Forum in Davos, Switzerland, researcher and inventor Nicholas Negroponte presented his $100 laptop to the international community as a tool that would radically transform primary education in the developing world. This was the OLPC, the famous One Laptop per Child project[3].

Negroponte convinced the policy makers of the potential of his proposed solution and in November 2005, Secretary-General of the United Nations, Mr. Kofi Annan, pre-

3 Source: https://tinyurl.com/OLPC-Davos-2005, (accessed 31-07-2019)

sented the first prototype of the so-called *"XO laptop"* at the World Summit for the Information Society in Tunis, to an audience of about 17.000 people, amongst whom there were heads of states, representatives of international organizations, academia, civil society and the private sector[4].

Negroponte's invention had unique hardware. The XO laptop was equipped with novel features for power supply, display, networking, keyboard, and touchpad [208]. It had a screen that allows reading in bright sunlight. It was energy-efficient, using a solar battery. It was built to endure dust and heat. It was designed for use in a local area mesh network of only XO laptops, even without an Internet connection[5]. The estimated lifetime of the XO laptop was about four years[6].

OLPC presented itself as an educational project, not a "laptop project"[7]. The XO laptop was designed and produced by the OLPC organization as a scientifically grounded self-learning tool, based on the constructionist theory of learning by doing [223, 230]. Its claim was that the access to a connected laptop would engage children into knowledge acquisition[8].

The marketing strategy of OLPC persuaded many governments of developing countries to commission large-scale deployments of XO laptops for primary education. The largest deployment took place in Peru, where the national government spent 225 million US$ on OLPC's XO laptops[9]. In Uruguay 395.000 XO laptops were delivered to 2332 public primary schools, in 2009[10]. OLPC wanted to deliver the XO laptop in bulk only, with a minimum of 1.000.000 laptops per order, but this figure appeared too optimistic. In April 2007 OLPC lowered the minimum order to 250.000 laptops [41].

The XO was nicknamed the *$100 laptop*, but its actual unit price was 160 US$, not including deployment costs, maintenance and training of teachers [220]. Nicholas Negroponte estimated that, by the end of 2007, 150 million of these laptops would be shipped annually[11].

After its hyped entrance into the international development stage [206, 41], various difficulties were reported for the OLPC project [220]. The evaluated pilots of OLPC deployments in Ethiopia, Haiti, Nepal, Rwanda and Uruguay reported difficulties in teacher-student relationships. Ethiopian and Haitian pilots reported that teachers encountered problems in using the constructionist teaching approach. The overall use of XO laptops in class remained limited, because of reluctance of schoolteachers to adopt the new teaching methods [220].

4 Source: https://tinyurl.com/OLPC-WSIS-2005, (accessed 31-07-2019).
5 Source: https://www.itu.int/net/wsis/c2/docs/may-18/06.pdf, (accessed 31-07-2019)
6 Source: http://one.laptop.org/about/hardware, (accessed 31-07-2019)
7 Source: http://laptop.org, (accessed 31-07-2019)
8 Source: http://wiki.laptop.org/go/Education, (accessed 31-07-2019)
9 Source: http://www.economist.com/node/21552202, (accessed 31-07-2019)
10 Source:http://one.laptop.org/map/uruguay, (accessed 31-07-2019)
11 Source: http://news.bbc.co.uk/2/hi/technology/4292854.stm, (accessed 31-07-2019)

Evaluations of local XO deployments have been performed in various countries (e.g. [220, 322, 206]) to assess the various deployments and measure the impact of XO use on children's cognitive skills. Some studies indicated that marginalized students were less capable of exploiting the XO's potential than students with higher socioeconomic backgrounds, and pointed at the fact that the XO was exacerbating existing divides [322].

In 2012 an impact evaluation of the OLPC project was done by the Inter-American Development Bank in Peru [98]. A randomized control trial study was performed for test scores in math and language of children from 319 primary schools in Peru. The evaluation of the impact on children after 15 months of exposure to the XO showed only a slight increase in cognitive skills that could be attributed to the XO laptop. Obviously, the computer/student ratios in this evaluation study showed a considerable rise: from 0.12 to 1.18 [68].

After an evaluation study of OLPC between 2009 and 2013 at two schools in Ghana, investigators Leslie Steeves and Janet Kwame (2017) commented: *"The history of OLPC illustrates how projects in the developing world commonly unfold. A small handful of powerful government and development leaders, usually men – in this case, Ghana's late Finance Minister Kwadwo Baah – Wiredo, former president John Kufuor, Nicolas Negroponte, and Jeffrey Sachs – are taken with an idea and deploy the resources to carry it out, without broad consultation and certainly without engaging the agency or voice of recipients at the grassroots"* [297].

According to various studies OLPC suffered from a lack of complementary infrastructure, skills development for teachers and students, and adaptation to local practices and constraints [126, 68, 7].

2.2.2 *OLPC and user participation*

Notwithstanding the claim of the OLPC organization that the XO laptop was developed to fit 'the developing context', with its rugged, robust hardware, its low energy consumption and its bright green colors to prevent it from theft, the whole idea – including hardware, software and educational concept – had been developed in the Global North. The XO was invented, designed and produced at large-scale, and subsequently rolled out in developing regions.

The implementation of the OLPC project follows the "classical" linear model of innovation, which has been described by economists such as Schumpeter (1911), Ryan and Gross (1943,1950) and Usher (1954), [285, 272, 271, 312]. According to this model innovation is a "linear", one-way process, consisting of several steps. First there is an idea by an inventor or expert. This is followed by a phase of research and development. Then comes production, deployment, marketing, and finally diffusion and adoption by users (see Figure 4).

This model of innovation is nowadays considered outdated, since recent studies have presented alternative models, in which innovation consists of a nonlinear, networked

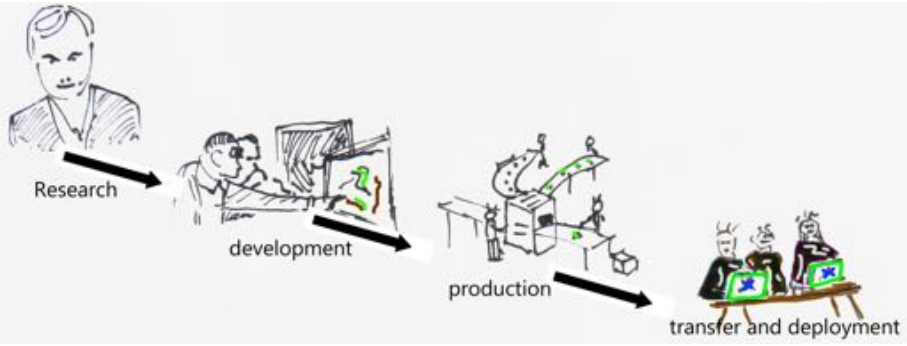

Figure 4: A conceptualization of the linear model of innovation, which was used in the development and roll out of the OLPC.

process of social change, characterized by iterative cycles of communication, learning, and feedback [281, 103, 308, 320, 251, 202].

The OLPC's XO laptop was implemented as a large-scale transfer of technology without participation of real users in the formulation of goals and objectives and without user-centered requirements analysis. It was designed according to assumptions that were not validated by local users. The OLPC project is a typical example of a top-down, linear intervention.

2.3 ISSUES OF CONTEXT

The introduction of computers and the Internet in poor regions is often thought to improve people's access to information. Yet, the following cases show a mismatch between the transferred technologies and the local context.

2.3.1 *Telecenter projects: rolling out ICTs in poor environments*

Rural poverty is commonly associated with a lack of information: e.g. on markets, customers and prices, agriculture practices, inputs, best practices and opportunities for microfinance. To improve information access for poor rural communities, ICT4D is often proposed (e.g. [309, 274, 140]).

To connect the rural poor, community telecentres have been rolled out in many developing regions, since the 1990s [140]. Examples of telecentre projects are Bario[12] in Sarawak, OMAK ICTs for the empowerment of indigenous women in Bolivia[13], Timbuktu Multi-Purpose Community Telecentre Mali[14], and Gyandoot[15] in India.

12 Source: http://www.ebario.org/ebario-telecentre.html, (accessed 31-07-2019)
13 Source: http://www.bridge.ids.ac.uk/global-resources/resource/A52945, (accessed 31-07-2019)
14 Source: https://tinyurl.com/k72r85q, (accessed 31-07-2019)
15 Source: http://www.dhar.nic.in/gyandoot.htm, (accessed 31-07-2019)

Telecentres are physical service centers that provide facilities such as email, web browsing, office applications and printing, to local communities. Telecentres are extensively described in development literature, as for example: *"... a mechanism which uses ICT to support a community's economic, social and educational development, reduce isolation, bridging the digital divide, promoting health issue and empower women"* [11]; or "[telecentres] *give rural communities an opportunity to adapt to new technologies and use those technologies to suit their real needs.*" [64].

Telecentres are typically equipped with personal computers and Internet connectivity. Sometimes fax, radio, television and telephony are part of the equipment. Some telecentres provide training in the use of mainstream computer applications and computer use [135]. Telecentres are commonly financed or subsidized by governments, development donors or through private funds, in contrast to Internet cafes, which are commercial service centers, located in urban areas [11, 135, 115].

In Rwanda, the national government launched a program in 2005 to establish telecentres all over the country as an intervention to improve conditions in rural areas. Up to 90% of the population in Rwanda consists of rural dwellers, living from subsistence farming [293]. The estimated adult literacy rate in Rwanda is 65 percent[16]. However, in rural regions literacy is estimated to be not more than 50% [219]. About 70-90 % of the population speaks only Kinyarwanda language [275].

The telecentre project was part of a technology oriented policy by the government of Rwanda, in which one billion US dollar was invested in ICT and technological innovation for the reconstruction of society through rapid socio-economic development, in the aftermath of the war of 1994, in which a million people were killed and all basic infrastructure of the country was destroyed [42].

Between 2006 and 2012 thirty government rural telecentres were installed all over the country. An extensive research of the telecentres of Rwanda was done by Seth Buhigiro in 2012. He visited the rural regions and wrote a case study about community telecentres in rural regions of Rwanda, including the Gicumbi, Rulindo, Nyabihu, Kayonza, and Huye telecentres.

Seth Buhigiro reported positive findings from his evaluations, mentioning that telecentres provide Internet access to people who were previously deprived of ICTs. The major constraint to the use of telecentres is the widespread illiteracy of the rural population, and the variety of local languages spoken by the majority in rural areas. Also the relatively high cost of telecentre services is a barrier for the poorest people [42]. This shows how the main barriers to information access have remained for those who were considered the actual target group of the intervention.

As one of the interviewees in the rural telecentre remarked:

> *"... yeah, users have challenges such as language problem, most of the people here speak Kinyarwanda and French language, and yet to use Internet and learn computer programs*

16 Source: http://www.unicef.org/infobycountry/rwanda_statistics.html, (accessed 31-07-2019)

> *the user must have basic knowledge of English. Secondly adult people are not skilled with computers and they find it difficult in adopting to the use of ICTs such as Internet, and other administrative services such as word processing, excel, and powerpoint to assist them in their day to day activities. Thirdly, telecentre cost of charge to some services such as Internet, scanning, and fax is a challenge to some of the users especially those who are unemployed and local farmers..."*[42].

A staff member of another rural telecentre in Rwanda expressed the following concern:

> *"... this is a rural area, most of people are not educated, they do not know how to read and write and using telecentre is a challenge to them. Language is another issue for those who cannot read and write; the majority speaks Kinyarwanda and some speak French and yet the content is in English. This has been the major challenge to the user point of view..."*[42].

2.3.2 *Maji Matone: SMS text-messages to improve water quality*

Lack of understanding of the local context is an important risk factor for mismatches between proposed technology and context. One case has been reported from a three-year project in Tanzania, the Maji Matone project[17] which started in 2009[18]. This project aimed to improve the quality of water in the benefit of rural communities in Tanzania. In the course of this project, people from local communities were requested to send feedback to the project organization, on the state of drinking water. They should do this using SMS text-messages. These data would be processed and used to inform the local government about the water quality.

Although the project implementers expected that 3000 SMS text-messages would be sent out by the community members, only 53 were issued. Two reasons were identified for the lack of success. Firstly, the project designers had not taken into account the poor mobile coverage in the region. Secondly, water collection turned out to be a task of women and children, who did not own a mobile phone, and so could not report the requested information to the project data store[19].

A proper needs assessment and context analysis before the start of the project might have revealed the mismatch in a much earlier stage. A flexible project structure or attitude might have led to adaptation of the planned activities during project execution. Involvement of local villagers in the project design would have led to a different project design, or even to alternative objectives, but would certainly have prevented the poor result.

17 Source: http://www.daraja.org/our-work/rtwp , (accessed 31-07-2019)
18 Source: http://transparency.globalvoicesonline.org/project/maji-matone, (accessed 31-07-2019)
19 Source: http://tinyurl.com/vulnerability-poverty, (accessed 31-07-2019)

2.3.3 *Mismatch between technology, needs and context*

A mismatch between deployed technologies and actual local needs and context is a recurrent problem of ICT4D projects (e.g. [71, 21, 126, 306, 5, 192]). As illustrated by the case of telecentres in Rwanda and by the water project in Tanzania, the proposed solutions may not be meaningful, the deployed technologies may not fit the local infrastructure or the systems may be useless e.g. due to issues of language or illiteracy. The total cost of ownership of the technologies may be too high, making the project financially unfeasible after donor-funding ends [165]. Some interventions lead to unequal benefits in which some stakeholders become disadvantaged, as the result of the intervention [318].

Pressed by the urgency to scale up and achieve measurable results within the project period, development agencies and donors often favor "one-size fits all" solutions, not based on a proper context analysis and without adaptation to specific contextual conditions. This can be observed in e.g. the OLPC, Maji Matone and Rwanda telecentre projects.

Remarkably, many practitioners in development and ICT4D uncritically overlook this rather biased and narrow view on development which is expressed by the interventionist approach. A reason for this bias may be the fact that – at least for the implementing agency – the project donor represents the "customer", i.e. the organization that funds and sets the project objectives. "Customer satisfaction" in the case of donor-funded ICT4D equals "donor satisfaction". This makes the implementing agency less inclined to carefully listen to the end-users or try to satisfy their specific needs.

2.4 HOW ARE GOALS CONSTRUCTED?

The above cases show that ICT4D projects do not involve users in the process of innovation, and do not take contextual variations into account. But what about the definition of project goals? Are end-users and beneficiaries involved in the formulation of objectives that concern and affect their livelihoods?

In the following section the Millennium Villages Project (MVP) is discussed and assessed. This is a high-profile, multi-country development project that aims to demonstrate that rural poverty in sub-Saharan Africa can be solved through financial investment and massive introduction of technologies from the Global North [276, 273].

2.4.1 *Millennium Villages Project: an intervention to eliminate rural poverty*

The Millennium Village Project[20] was set up in 2005 by the Earth Institute, Columbia University in New York, the UNDP[21], and a non-profit organization called Millennium Promise[22]. In line with the United Nations Millennium Development Goals (MDGs)[23] [24] the MVP was presented as an initiative to lift development country villages out of a 'poverty-trap'. Its target groups were mainly subsistence farmers in sub-Saharan Africa, with a daily income of 1 or 2 US dollar per day. This included communities in various regions, ranging from rainforest margins to pastoralism on arid lands [276, 273]. This high profile project, which was the idea of development economist Jeffrey Sachs, aimed to achieve quantifiable results within ten years.

MVP started implementation in a small village named Sauri, in Kenya, soon followed by a village in Ethiopia, named Koraro, in February 2005. In 2006 the MVP was extended to Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania, and Uganda, covering seventy-eight villages, and targeting a population of 500.000 people [276]. These regions were selected for having a high percentage of underweight children [242]. Baseline studies and household surveys were carried out in each village. The population was categorized according to classes of relative wealth [276, 273].

To increase local agricultural yields the MVP supplied 'scientifically proven western agro-technologies' such as modified hybrid seeds and artificial fertilizers [276]. The inputs were subsidized by the project, as a replacement for traditional indigenous species which are commonly used. Local farmers received training how to apply the new technologies. Meanwhile, roads and power infrastructure were built, mobile telephony and Internet were installed and free anti-mosquito bed nets were provided to households. Educational and health services were implemented. The MVP provided microfinance loans to selected households [276]. These interventions were carried out in each of the selected regions [276].

The estimated project budget for the MVP was 500 million US dollar, for a period of ten years. An average of 110 US dollar was spent per beneficiary person, per year [273].

The MVP applied commercial marketing strategies to present the project to the general public, e.g. using endorsements from celebrities including Bono, Brad Pitt and Angelina Jolie, by merchandising articles e.g. Millennium T-shirts from Tommy Hil-

20 Source: http://millenniumvillages.org (accessed 11-11-2017)
21 United Nations Development Programme http://undp.org (accessed 11-11-2017)
22 Source: http://millenniumvillages.org/millenniumpromise/(accessed 11-11-2017)
23 The global intention, ratified by all UN member states in 2000 to cut poverty, hunger, disease, gender inequality, environmental degradation, lack of access to safe drinking water and sanitation in the period of fifteen years.
24 Source: http://www.un.org/millenniumgoals/ (accessed 11-11-2017)

figer[25], and by continuous use of social media, Facebook, Twitter, blogs, podcasts and videos.

2.4.2 *Millennium Villages Project's construction of goals and objectives*

The MVP is an intervention that wants to bring about a particular change in a state of affairs. The actual state of affairs is formulated in terms of deficiencies: e.g. lack of technical expertise, lack of investment, lack of infrastructure, lack of knowledge.

After the needs identification the intervention is designed and planned. The intervention consists of a transfer of knowledge from a technical expert to a beneficiary group – this is referred to as capacity building – or transfer of technologies, goods or capital. Construction of new infrastructure is also part of the intervention [276].

The MVP describes the situation in the intervention area in terms of 'hunger, disease, gender inequality, environmental degradation, lack of access to safe drinking water and sanitation'. A sense of urgency is evoked, using terms as 'extreme poverty', 'extremely low productivity' and 'insufficient core infrastructure', and even a 'crisis in telecommunication' [276].

Sanchez et al. describe the MVP as a research project, in which the central hypothesis [276] is that 'poverty' in Africa results from lack of 'productive capital'. In the MVP's rationale, the so-called 'poverty trap' can only be overcome through financial investments that augment the capital stock of households and communities in rural Africa. The MVP project wants to demonstrate that investments at the level of 110 US dollar per capita per year, over the period of 5 to 10 years, will lead to an escape from the so-called 'poverty trap' [276].

But is this hypothesis-based research design of MVP flexible enough to allow adaptation of plans, in case new insights are obtained, during the project period? Suppose, for example, that the proposed investment-model proves to be harmful for certain groups of farmers? Suppose that zero-investment solutions would appear more successful for the farmers in the millennium villages, will the project give space for a community-based decision to refuse the artificial fertilizers and hybrid seeds which are supplied by the MVP, in favor of a locally produced, inexpensive innovation? Will the MVP's research set up be revised and altered in this case?

The MVP claims to be 'community-based', applying a 'participatory approach to planning, implementation and monitoring' that 'contextualizes the specific set of interventions for each village' [276]. However, its strategy is externally defined, as stated in MVP's main principles and strategy: *"Where adverse cross-sector tradeoffs are possible, there must be guidelines, incentives, or disincentives to minimize them"* [276] p.16776.

25 Source: http://millenniumvillages.org/field-notes/tommy-hilfiger-shirts-are-a-hit/ (accessed 31-07-2019)

The design and approach[26] of the Millennium Village Project reveal the assumptions that underlie this large-scale intervention: *change* is supposed to be brought about by an external entity (*in casu* an American development agency). It can be implemented in a limited time span (of ten years) and will yield a measurable difference. Actions can be applied anywhere, despite the different contexts.

Despite rhetoric about "participation", MVP does not take into account local agency. As illustrated by its project design, the intervention and transfer of technology are determined and decided upon by outsiders without room for definition of development goals and priorities by its beneficiaries.

2.5 COPING WITH ISSUES OF COMPLEXITY

The linear conceptualization of cause and effect, as illustrated in the above examples of ICT4D projects, is central to the interventionist logic. This holds various assumptions, quoting Preston [238] "*(i) the supposition that there is 'something' to be acted upon (ii) the expectation that 'it' will respond in a predictable fashion (iii) the idea that intervention can be accomplished, according to a clear set of expectations*", i.e. not accidentally, but intentionally, according to externally defined goals. But, is it likely that 'it' – in a complex, real world context such as for example rural Africa – will respond in a controlled and predictable way?

2.5.1 *Linear methods in international development*

Interventionist logic is rooted in international development, as can be observed in the project management methods that are prescribed and used. An example is the logical framework approach (LFA), a widely used project management method in international development [152, 12]. The logical framework approach was developed in 1969 by American development agency USAID, as an instrument to design and evaluate development projects. Since 1997 the World Bank, and many other organizations have adopted it as the standard tool for project appraisal [267].

The logical framework approach is a cause & effect model, based on a set of interlocking concepts and hypotheses. It assumes that development projects are instruments of change, which have been selected by the donor agency as the best and most cost effective action to achieve a desired, beneficial result [267]. The framework allows the donor to control the project, by monitoring and evaluating it according to a stepwise, linear method [163]. The core of the logical framework is its 'temporal logic model' in a series of connected propositions [267]. These propositions are set in a table – the logframe – which summarizes a development project[27]:

26 Bill & Melinda Gates Foundation and Rockefeller Foundation also support this approach, see e.g.: http://tinyurl.com/GreenRevolution-Bill-Melinda (accessed 11-11-2017).

27 Source: http://tinyurl.com/LFA-managers-guide-pdf (accessed 31-07-2019)

```
IF these Activities are implemented AND these Assumptions hold,
THEN these Outputs will be delivered;
IF these Outputs are delivered AND these Assumptions hold
THEN this Purpose will be achieved;
IF this Purpose is achieved AND these Assumptions hold
THEN this Development Goal will be achieved.
```

The framework breaks a project down into four levels of objectives: activities, outputs, purposes and goals. Activities of a project will result in outputs; several outputs are combined into achieving the project purpose; at a higher level, there is the goal. As such, the logical framework approach covers the entire project management lifecycle from design to project implementation and monitoring & evaluation.

The specification of purposes to achieve the goal, is the task of the program manager, who operates at the donor agents' hierarchical level[28]. Specification of outputs to achieve purpose is normally done at the implementation level, by a project manager.

Another project management framework with similarities with the LFA has been introduced in the 1990s in international development: the so-called "theory of change" (ToC) [113]. Similar to the logical framework approach, the theory of change describes a set of assumptions that explain the steps that lead (linearly) from problem to development goal. The ToC framework maps the connections between activities and outcomes, to a planned intervention [298]. The theory of change is a planning tool, which uses so-called "backwards mapping", a way of defining change as a long-term goal, and of identifying the intermediate and early-term changes which are required to cause this desired change. Through a paper-based (desktop) exercise a set of connected outcomes is created. This is known as *the pathway of change*[29].

The theory of change is increasingly used in international development project proposals, as prescribed by donors and development agencies [298]. It is also based on the linear ideas in which change is a direct, proportional, additive and predictable result of (development) interventions, following a cause – effect logic. Similarity between LFA and ToC is the emphasis on project management and impact evaluation (see also:[12, 8, 163]). Despite claims of flexibility, these frameworks confine and structure a project into a linear process, in which each step leads to a predictable outcome. Success or failure are determined by evaluating results against goals, with the use of preset performance indicators.

2.5.2 *Evaluating the effects of interventions*

Evaluations of international development projects are also framed by interventionist logic. Evaluations are carried out *after* (post-hoc) implementation, with respect to a

28 Source: http://tinyurl.com/Logical-fr-Handbook (accessed 31-07-2019)
29 Source: http://www.theoryofchange.org/ (accessed 31-07-2019)

"static" baseline, that pre-existed the intervention or action. Donor-funded development projects demand evaluations, in the first place, for accountability reasons, to assess whether an intervention is effective, how it contributes to change, and if not what should be improved and what are the lessons learned. Moreover, evidence is required to make sure that project funds have been well spent.

As "change" is thought to be brought about by an intervention, evidence is demanded, to which degree the change can be *attributed* to the intervention. According to an evaluation expert at the World Bank, Paul Gertler: "focus on attribution is the hallmark of impact evaluation" [113].

Evaluation studies of ICT4D can be qualitative, quantitative or a mix of these two flavours [288, 262]. Qualitative and mixed evaluation studies are often field-based (e.g. [171, 196, 207]). There is a large body of ethnographic studies that assess the impact of new technologies on people and society in developing contexts (e.g. [76, 57, 167, 115]). Another category of evaluation studies consists of qualitative desk research studies that evaluate ICT4D at a high conceptual level. These desk studies extract general trends from ICT4D deployments and provide sustainability frameworks to inform policy makers (e.g. [140, 144, 141, 192, 118, 72]). In general, these desk studies do not provide relevant guidance for on-the-ground improvements of ICT4D.

Quantitative studies, which produce "hard figures" are the preferred methods for evidence-based policy making in international development [113]. They are considered more convincing to policy makers and the general public than results of qualitative studies [262]. Various quantitative impact evaluation methods including randomized control trials (RCT), regression discontinuity approach [316], propensity scores [266] and various other (quantitative) methods are used [113]. These quantitative evaluation methods focus on (linear) causal inferences by calculating which percentage of the observed change is due to the intervention in question. These evaluation methods, however, do not answer the question *how* the observed change occurred, and what can be learned from the process [63].

An example of a quantitative evaluation method which is frequently used in international development, is the randomized control trial (RCT) (see also [226, 244]). Randomized control trials to assess the effects of a treatment originate from medical sciences and experimental psychology (e.g. [156, 226]).

The idea of this evaluation method is as such: an intervention A on a given development situation X causes outcome B. There are two control groups in situation Y and Z, which are assumed to have identical or at least comparable conditions as situation X, but are not receiving treatment by intervention A. After intervention A is finished, the measured performance indicators from groups X, Y, and Z are quantitatively measured, and statistically evaluated. If the perceived differences between the indicators of X, Y, Z are found to be significant, the difference is attributed to intervention A. Groups X,Y and Z are "randomized", and kept separated, to avoid "contamination" of the data.

This hypothesis-based approach to impact evaluation is based on the cause-effect logic. It does not allow adaptation of the project plans during implementation, as this will interfere and damage the trial and its underlying research set-up.

Robert Chambers questions the use of randomized control trials (which he calls "reductionist rigour" [53]) in development experience and practice, where:

> *"... receiving environments are diverse, controls liable to contamination, measurements difficult, causality multiple or intertwined and problems messy, wicked and not amenable to obvious or straightforward solutions. In short, what is rigour for learning about complexity? [53]"*

Another point against the use of randomized control trials in "real world" evaluations is made by Ray Pawson. In his book "Evidence-Based Policy" (2006), Pawson points at the limitations of simple causal inferences in real world contexts, where many different, interdependent variables may be at play. Pawson also shows how randomized control trials lack explanation power, on how interventions work in real situations. [226].

Colin Robson, in his book "Small-scale evaluation" (2017) ([262]), points at the ethical aspects of randomized control trials, e.g. by denying (prohibiting) a certain group of people (the so-called control group) the use of a promising technology or innovation, to avoid "contamination" of the study groups.

Innovation researcher Everett Rogers (2003) writes on the adoption of innovations that the overwhelming reliance on correlational analysis of survey data often led to avoiding or ignoring the mechanisms behind it [263].

In short, post-hoc evaluations are based on the idea that an intervention produces a predictable, observable change that can be attributed to the action. Quantitative methods are aimed at attributing the observed change to the intervention, but do not provide guidance to improve the project *during* during its lifetime.

Qualitative, field-based evaluation methods such as case studies, (by some researchers labeled as"anecdotic" (e.g. [140, 63, 113]), process evaluation [262], mixed methods, participatory evaluation methods including adaptive iteration, triangulation, plural perspectives, field visits and many other eclectic methods (of inclusive rigour according to Chambers (2015) [53]) can give deeper insight in complexity of (interdependent) contextual factors, in the underlying mechanisms of the change processes, especially when performed during project execution, and not post-hoc [263, 53].

2.5.3 *Linear models in ICT in the Global North*

Interventionist methods are not restricted to international development. They are also known from e.g. healthcare, education, military warfare, organizational management and ICT [269, 15, 244].

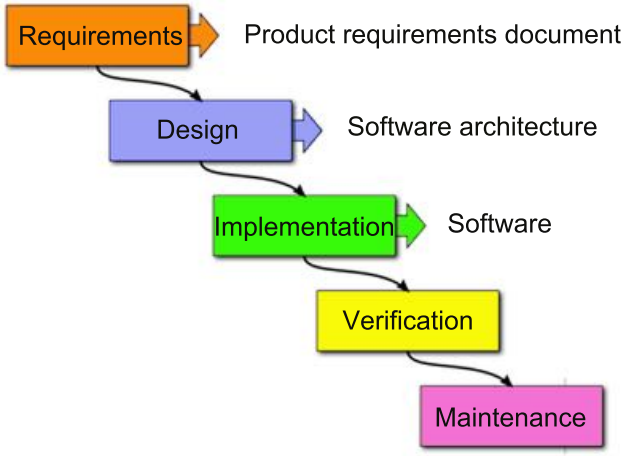

Figure 5: Conceptual diagram of the linear, waterfall model, consisting of five phases of software development. Adapted after a diagram by Peter Kemp and Paul Smith, source: https://en.wikipedia.org/wiki/Waterfall_model, (accessed 31-07-2019)

In the 1960s and 1970s, a linear, top-down method, named the waterfall model – with large similarities with the logical framework approach – was widely used in the ICT (business and industrial) sector in the Global North. The waterfall model was used in software development to centrally manage, plan and control large-scale ICT projects [269]. According to the waterfall model, software development consists of a series of sequential stages: (i) a plan is made, (ii) requirements are agreed upon, (iii) a design is created, and code is written accordingly; when coding (i.e. implementation) is finished, (iv) the software is tested and verified against the pre-set requirements and design, (v) the system is rolled out, and maintenance can start [180]. These steps can be visualized as a waterfall, see Figure 5.

The waterfall model is orderly and looks logical and sound. It has shown to work well in the (special) case of standard, predictable software development projects, in which user needs and requirements are fully known at the start of the project [178]. As this condition (of full understanding of requirements) is seldom the case, certainly not in innovative projects, in complex contexts or in large software development projects where built-in flexibility and adaptability are required, the waterfall model turns out unsuccessful [228]. Flexibility and adaptability are fundamentally absent in linear models such as the waterfall model.

The waterfall model has been held responsible for high rates of failure in large ICT projects and software developments. Various studies showed that 80 to 85 percent of ICT project failures are due to incorrect or changing requirements or lack of user involvement [181, 185].

In ICT4D policy and programs "linear" (waterfall-type) approaches are still common (as illustrated by projects such as the OLPC and the MVP). Various ICT4D studies

propose "linear" models. An example of a step-wise model for ICT4D that describes a linear path from strategy to implementation, to adoption/use/sustainability/scalability and impact, is the "ICT4D value chain", [140, 144, 143]. In this linear model, that aims to inform development policymakers, the "exogeneous factors" (what I would refer to as the *contextual* factors), are positioned (conceptually) in the latest stages of the chain, between the phases of outcomes and impact (see [144]). Since context analysis is not positioned in the design phase of this model, this model implies that the technologies are invented elsewhere, without concerns for contextual complexities on the ground and then transferred to the developing region.

Nowadays, in various domains adaptive methods and strategies for coping with complexity, dynamic contexts and uncertainty, have been introduced. For example, in software engineering and technological innovation agile methods have emerged as a reaction to plan-based methods and rationalized, engineering-based approaches that were dominant, especially in the 1960s and 1970s in large-scale software development projects [87, 181]. Agile methods address the complexity and unpredictability of the real world. Whereas the linear approaches focus on purposive planning and action, "adaptive" or "interpretive" understandings such as agile methods recognize the need for continuous reconfiguration and realignment to ever changing environments [201].

2.5.4 *Linearity versus complexity*

The point that linear frameworks are inappropriate to deal with the complexity of "how the world works", is already made in various studies, although not specifically for ICT4D [244, 15, 175, 50]. For example, Robert Chambers (2010), in his book "Paradigms, Poverty and Adaptive Pluralism" [50] shows the inappropriateness of blueprints and planning, pre-set and closed goals, centralized decision making, reductionist analytical assumptions, and standardized universal methods and rules, which are commonly applied in rural development. Chambers attributes widespread failure in development projects to the dominance of the so-called 'things paradigm', a way of imposing standardized methods on uncontrollable and unpredictable conditions of real-world contexts and people. Chambers proposes to introduce system's thinking and a people-centered approach, and ensuing bottom-up processes and participatory actions, in international (rural) development [50].

Studies in complexity research, over the past decades, have focused on the structure and behavior of nonlinear systems as they are observed in social, biological, physical, chemical, ecological and other contexts (e.g.[240, 112, 149, 197, 172, 174]). These are called complex systems or complex adaptive systems, in which "adaptive" refers to the fact that these systems are exposed to external influences, dynamic, and adaptive to change [150]. Complex systems do not follow blueprints, but evolve over time [240, 241]. Small changes in a complex system can result in disproportionately large effects [240, 15, 149, 184, 183, 173]).

Complex (adaptive) systems exist at various scales of magnitude and are characterized by large numbers of interacting components or "agents": people, bacteria, ants, molecules, organisms, cells, etc. depending on which type of system. Agents interact and exchange information according to simple rules, but without a central controlling mechanism [149]. Agents display a form of organizational learning in which selection and re-invention lead to new rules and emerging characteristics [197, 172]. Self-organization, localized interactions of agents and feedback loops that create higher-level emerging patterns are characteristic for complex systems [240, 241, 172, 150].

A complex adaptive system is able to adapt itself dynamically to changing environmental conditions [149]. Whereas cause & effect relationships in linear systems are smooth and proportionate (which makes them measurable and predictable [164]), this is not the case in complex adaptive systems. Anticipating, designing and planning the behavior of these systems, have shown not to work [15]. This does not mean that complex adaptive systems are totally unpredictable and unmanageable. According to complexity researcher Bar-Yam there are no "best practices" to tackle complexity. Each situation requires a different solution. Distributed/networked organizations are best equipped to solve problems in complex adaptive systems [15].

Developing regions can be conceptualized as complex adaptive systems. They are dynamically governed by factors (variables) which interact at various scales: the global scale (e.g. climate, economy), the national scale (e.g. politics, legislation, economy), the local scale (the environment, social networks), the human scale (livelihoods, households, people) [79, 290, 245].

Developing regions, for example in rural Mali, consist of interacting agents: people in their social networks, acting at various scales. There is a high level of heterogeneity in people's behaviour. A central coordination of human behavior is absent. The rural environment is dynamic, open and constantly changing and adapting to new conditions under internal and external influences. Emerging patterns, which result from the aggregated behavior at lower levels, can be observed in landscapes, agriculture, communities, urbanizations, culture, language, economy, politics, infrastructure, social networks etc. Development interventions that target one of the many factors or, more specifically an ICT deployment in such a complex context, need careful consideration to avoid unexpected and unintended side-effects.

2.6 DIFFUSION OF INNOVATIONS

As agents in a complex adaptive system, people interact, build relationships, exchange knowledge through strong or weak links [123], in social networks that evolve over time. The aggregation of all human agency leads to emerging patterns and larger-scale phenomena, which we can observe in the world around us [241, 150, 15, 198, 197].

One of the observable phenomena in social networks is *diffusion of innovations*. This is a process in which an innovation is communicated through certain channels over

time among the members of a social system or network [263]. In recent studies large similarities have been observed between complex adaptive systems, social networks [198, 197] and diffusion of innovation models [264, 67].

The term "innovation" can mean various things: it may refer to a technology or artifact, but also to an idea or practice. Innovations are adapted, reinvented and adopted, while they propagate through the social networks. Diffusion of innovations occurs over time according to an S-shaped rate of adoption curve [263]. Diffusion of innovations is a general process, i.e. not bound by the type of innovation, who the adopters are, or by place or culture ([263], p xvi). The rate of adoption changes over time, which classifies the adopter in the following adopter categories: innovators, early adopters, early majority, late majority, laggards [263]. The "critical mass", is the point in time, during diffusion, after which the process becomes autonomous and self-sustaining [263, 13].

Diffusion of innovations is a major discipline in the field of behavior research. Diffusion of innovation studies took off in the 1940s-1950s, first as a branch discipline of rural sociology. This was commissioned by the US government as to obtain more knowledge on the process of diffusion and adoption, to improve the (then highly centralized) national extension services for agriculture, that aimed to make farmers adopt newly invented agricultural practices and technologies [272, 271]. For decades the classical, linear model for diffusion of innovations was the dominant model amongst researchers, policy makers and change agencies ([263] p. 394). Studies were aimed at understanding how adoption works, and how this can be improved, scaled up and made more efficient. In the course of the years, new insights have emerged on the process of innovation and its diffusion. Innovation research has expanded to other domains including technology, public health, education, international development, business, media, entertainment. The similarities between the diffusion of innovations model as an open, evolutionary, nonlinear system, and complex adaptive systems have been identified [264].

A breakthrough in innovation research was marked by the advent of the worldwide Web in the early 1990s. Internet and Web have not only changed the nature of the diffusion process itself, but have also brought new insights in this field of research. Nowadays much is understood about the properties of *decentralized* innovation. This is the process in which innovations bubble up somewhere and spread horizontally via peer networks with a high degree of reinvention, as the technology or artefact is modified to fit the particular conditions of the users ([263], p. xviii).

Innovation research is relevant for ICT4D, as it provides insight in the process of adoption, users, and information-sharing processes. In diffusion of innovation a number of variables are at play: the properties of the innovation or technology itself, the social networks where it is diffused, the characteristics of the adopter categories, and the way how information is spread and shared over the members of a social network [263]. This has to be taken into consideration, when developing, building, testing, evaluating technologies for users in low resource environments.

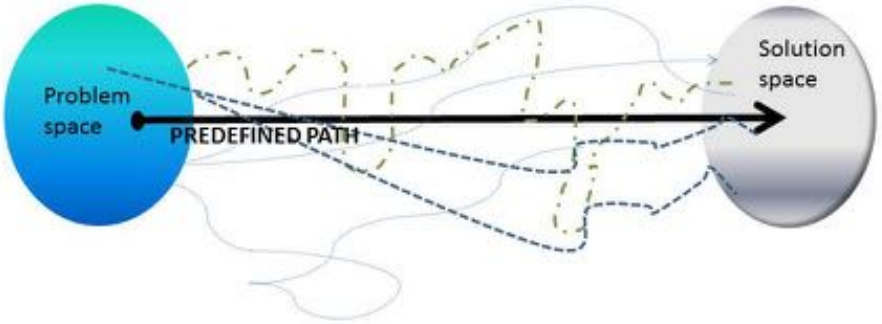

Figure 6: A conceptualization of many possible alternative paths between problem space and solution space.

In the latest edition of his book "Diffusion of Innovations" the late innovation researcher Everett Rogers (2003) compared decentralized diffusion with highly centralized, top-down interventions. He perceived that decentralized systems are more likely to fit users needs and problems, as users feel a sense of control when they participate in making key decisions, for example: which of the perceived problems most need attention, which innovations meet their needs, how to seek information and from which sources, ([263], p 398). These observations hold important lessons for ICT4D developers and policy makers, when developing information services to "connect the unconnected" people.

2.7 MULTIPLE PATHS TO INNOVATION

As shown in the previous sections, the logics of interventionism is built on a cause-effect model in which an intervention has a clear and measurable effect. The interventionist approach, the linear project management methods and the cause-effect evaluation models used in ICT4D all have in common that they confine the *solution space* to one single point, which must be reached, following a predefined path from problem to solution. This holds the (ungrounded) assumption that there is a complete understanding (by the implementers) of the end-users' problem, at the start of the action.

In contrast, adaptive approaches are based on a different world view. They can be conceptualized as follows: given a certain (real world) problem there is a *solution space* which can be explored. A large number of possible paths from a problem to an acceptable solution may exist. Since the outcome of an innovation is not known beforehand, its trajectory cannot be predicted. An innovation process typically consists of exploration, iterative loops of action, testing, adjustment and re-invention until finally an acceptable solution is found.

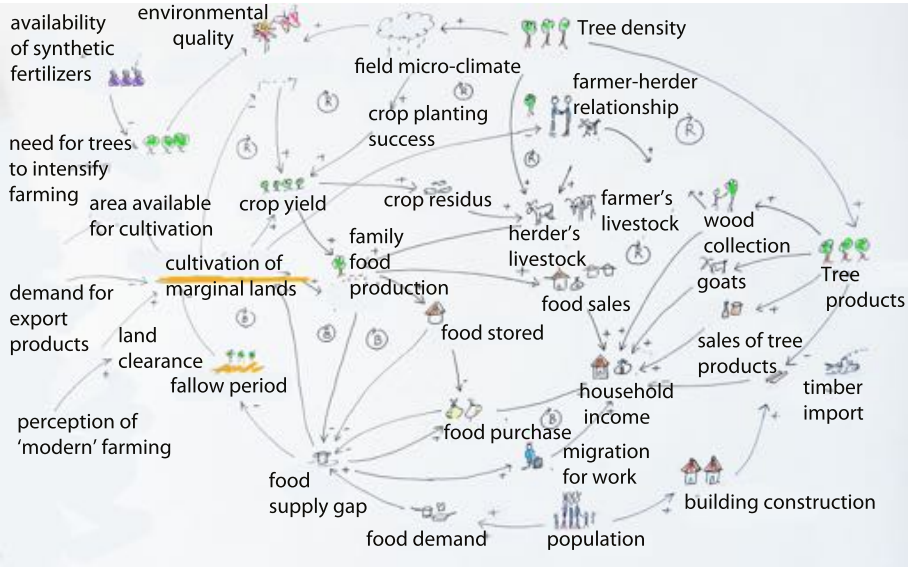

Figure 7: Conceptual model of complex interactions in the Sahel. Variables are influenced and influencing causing complex feedback loops of interactions. If a causal loop sustains the direction of change it is labeled R (reinforcing). If it reverses the direction of change, it is labeled B (balancing). Adapted after a model by Sendzimir, Reij & Magnuszewski (2011) "Rebuilding Resilience in the Sahel: Regreening in the Maradi and Zinder Regions of Niger" *Ecology and Society* 16 (3): 1, Fig. 6. [290].

A simple problem-solution model is shown in Figure 6, showing multiple paths. The straight line represents the ICT4D action, predefined from start to end as described and prescribed by the logical framework approach, using predefined performance indicators to monitor, measure and evaluate result. This approach does not consider that the solution space may be wider, but not fully known at the start of the action. It also does not allow deviations from the path when new information becomes available and new knowledge is generated during the time frame of the action/project. The dotted, curved and curled lines represent iterations and alternative solutions which are based on iterative adjustment to new situations and progressive understanding, possible feedback loops or improved solutions. In contrast with linear models of innovation and transfer of technology, the adaptive model is built on the idea that innovation is an evolutionary path which is iteratively adapting to users' requirements and changing contexts. This reflection on linearity and complexity gives an idea about the limitations of interventionist projects.

Linear cause-effect models have been criticized for being inadequate in real world research, for example, by Orlando Fals-Borda who did participatory action research with poor farmers in rural areas of Colombia [93].

An illustration of the shortcomings of linear cause-effect models in the complex context of rural West Africa is given in a study by Sendzimir et al. (2011) [290] on the root

causes for change in land-use in the Sahel[30]. For this study a system approach was used, based on data from different sources: long-term rainfall indices, trends on population growth, historical facts on droughts, famines, locust outbreaks, political trends since colonial times. Recent remote sensing data were compared with historical data to assess differences and trends in tree density [290]. This study demonstrates how many interconnected chains of causalities result in emerging webs of interactions [290]. A causal-loop diagram in Figure 7 visualizes the multiple interacting factors. The conclusion of this interdisciplinary system analysis is that, in this context, interrelationships between ecological, economic and socio-political variables exist, which are both cause *and* effect, through complex (causal) feedback loops. Impact evaluation studies with a more limited scope, (e.g. evaluating one variable only) the observed change is explained as a single cause-effect chain, whereas, in the real world a whole network of variables is interacting and reinforcing or balancing effects.

This study by Sendzimir et al. shows that, to deal with the complexity of a development context such as, for example, the Sahel of West Africa, a linear intervention may not be adequate. An approach is needed, which is more capable to cope with the non-linear realities of the given context.

2.8 SUMMARY

In this chapter we discussed a number of policy obstacles at the root of international development and ICT4D: the imposed operational frameworks for project and program management (linear waterfall model, logframe); the end-users or "beneficiaries", not treated as independent actors in their own right, with their own specific interests, contexts, values; a hegemonic discourse whereby interventions from outside are framed as the way of bringing about desirable change.

Despite advances in complexity and innovation research, "linear" (waterfall-type) approaches are widely applied in international development projects. Linear, top-down project management methods, such as the logical framework approach (see section 2.5.1), which is prescribed to project implementers by donor agencies for reasons of transparency and control; methods for post-hoc evaluations used to compare the observed change with respect to a project baseline as to attribute the observed impact to the intervention in a linear cause-effect way without considering the unpredicted side effects: these are all characteristic of the interventionist approach. This critique applies to development in general, ergo, also to ICT in development. This is what in this book is referred to as "mainstream ICT4D".

In contrast, a networked process of sociotechnical innovation, in which systems and services are developed according to goals and needs of users and their context, demands a different approach than the conventional *transfer of technologies*. It must (i) be able to cope with dynamic contexts of high uncertainty and complexity, and (ii) be

30 The Sahel is the region where our ICT4D field research took place.

reflective and critical, based on deliberation, as to deal with social contexts in which knowledge is not value-free. In the next chapter a number of established methods and approaches are reviewed, from a variety of research traditions, which meet these two basic requirements.

3

ALTERNATIVE METHODS AND APPROACHES

When developing ICTs in low resource environments, the developer has to cope with changing contexts and realities on-the-ground, and do justice to perceptions, values, and interests of people that directly matter: the supposed beneficiaries. To meet these requirements, we reviewed various modern approaches that do justice to complex, changing contexts and realities on-the-ground, and place the user at the center of the innovation process. There are state-of-the-art information systems engineering bodies of knowledge. Others come from development-related critical and participatory action research. The methods have in common that they avoid linear, deterministic and mechanistic views. They are also useful to put the Principles for Digital Development into practice[1].

3.1 INSPIRATION FOR A COLLABORATIVE, ADAPTIVE APPROACH

Our research seeks to design *an operational approach to developing ICT systems and services, such that it (i) takes into consideration the complex realities of local context, and (ii) involves the envisaged users in decision-making and sociotechnical development.* This approach is inspired by a number of ideas from various sources: some from ICT, software development or technology innovation, others from rural development practice. We will review a number of these ideas in this chapter.

3.2 COLLABORATION WITH USERS, ADAPTATION TO CONTEXTS

Collaboration with users and adaptation of technologies to context are key factors for successful innovation, yet, in ICT4D programs and projects the creative capacity of end-users is still largely untapped.

In software development and technology innovation it is nowadays common practice to involve end-users in the process of developing technologies. End-user involvement has proven crucial for the generation of ideas and new solutions [320, 19]. In e.g. the domains of industry, business, organizational management and ICT, many user-centered methods have been developed over the years. There are methods to structure and manage two-way information flows, or to bridge the gap between developers and users. There are methods that provide insight in local contexts [89]. What can ICT4D learn from these methods?

1 See: https://digitalprinciples.org/, (accessed 31-07-2019)

To answer this question we will review a few examples of user–centered, adaptive and collaborative approaches, from various domains of (high-tech and low-tech) innovation.

3.2.1 *Living labs*

Living labs are spaces for technological innovation [19]. One of the definitions of living lab is *"a user-centered research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts"* [89].

Initially, living labs were experimental environments, used to observe people (users) and their patterns of interactions, during the phases of design and evaluation of experimental, technology-rich homes and other smart real life contexts [19][2]. Nowadays, living labs are spaces where the innovative capacity of end-users is used for co-creation of new products and services.

Living labs are used in many different sectors, e.g. ICT-development, health care, rural development and industry. Each sector or domain uses living labs in an adapted way, so that it fits the specific needs.

Open innovation projects by firms and industries frequently use living labs – often in consortia or communities of practice – including different types of stakeholders (e.g. industry, academics, government, civil society) [100]. The purpose of these collaborations is to learn from external ideas and increase the ability to innovate (e.g. [320, 19]).

Despite various types of implementation, the overarching characteristics of living labs are (i) engagement of users in innovation; (ii) methods to elicit and capture domain-based knowledge; (iii) elicitation of new meanings and understandings; (iv) methods for capturing tacit knowledge; (v) understanding of and validation of ecosystems [6].

3.2.2 *Agile methods*

Adaptive methods and strategies for coping with complexity, dynamic contexts and uncertainty are used in various domains of (social and technical) innovation. In software development these are grouped under the umbrella of *agile development methods*.

Agile methods have emerged as a reaction to plan-based methods and rationalized, engineering-based approaches that were dominant, especially in the 1960s and 1970s in large-scale software development projects [87, 181]. Agile methods, in contrast, address the complexity and unpredictability of the real world. Whereas the linear approaches focus on purposive planning and action, "adaptive" or "interpretive" understandings

2 The term living lab is used both for the methodology and for the environment where the experiment takes place [19].

such as agile methods recognize the need for continuous reconfiguration and realignment to ever changing environments [201].

Agile methods – as the word *agile* suggests – are flexible, light-weight and adaptive. They avoid as much as possible bureaucracy and procedural tasks. Social interaction, collaboration, co-ordination and communication are important elements. Communication in agile development is usually informal, face-to-face, predominantly verbal, and sometimes even tacit (e.g. observing users perform tasks, or giving demos) [291]. Agile methods recognize the value of people and their relationships [210].

Agile development methods consist of iterative cycles – rapid building of prototypes and showing them to the envisaged users to collect their feedback for improvement. Solutions are designed, built and improved together with end-users [124, 256, 328]. Agile methods foster creativity and focus on quick responses to deal with dynamic environments and changing requirements [85].

Since agile methods have been applied in many different settings, no clear-cut definition can be given [85]. For some people "Agile" is a set of technical practices, for others a project management style, a philosophy, a set of collaboration practices that cater for the needs of customers and end users, or even a set of principles and values of professional conduct[3]. The following subsections give a few examples of agile-related methods.

3.2.2.1 *Non-hierarchical team work*

Agile software development is an inherently social endeavor in which team spirit and group work are important aspects. Teams are small (e.g. 5 - 10 people, depending on the type of task) and non-hierarchical. One practical method to organize teams such that they can tackle complex projects, according to agile principles, is the "scrum method" [259]. Scrum teams are self-organizing – not directed by managers or coordinators outside the team – and choose for themselves how they can accomplish the task. Scrum team members may have different/complementary skills, as to jointly accomplish a common task. Scrum teams are known for their flexibility, creativity and productivity. Tasks are carried out iteratively, in short feedback loops. Scrum was originally developed for software development projects, but is nowadays being used in different types of (complex) projects[4].

3.2.2.2 *Use case and requirements analysis*

A "use case" is a formal description of the interaction between user and software system. Defining use cases and finding requirements is a central task in software development. Use case and requirements analysis is an inherently sociotechnical activity that

3 From: Hakan Erdogmus' foreword in the book *Agile Development Methods* [85].
4 Source: https://www.scrum.org/resources/what-is-scrum (accessed 31-07-2019)

requires collaboration between developers and users. This can be organized through co-creative workshops [190, 296].

Non-technical users find it often difficult to describe requirements for a technological solution. To overcome this problem, a variety of elicitation techniques have been developed, such as prototype demonstrations, story boards and non-formal modeling. These methods are used to encourage brainstorming, define requirements and validate the actual design together with the users [181, 122, 121].

3.2.2.3 *Context analysis*

Context analysis is an inherent aspect of methods such as agile software development and living labs. Context knowledge about the end-users' environment is obtained e.g. by visiting the user *in situ*, e.g. by organizing so-called roadshows during which demos are given and prototypes of technologies are shown. Roadshows may encourage brainstorming and improve elicitation of requirements and facilitate design. Roadshows often have a social aspect, in which developers and users, who often have different viewpoints or conflicting views on software's features and functionality [209] get to know each other and start to collaborate and exchange ideas in an informal way [291].

Despite the importance of context, the actual activity of doing a "context analysis" is not an explicit task in innovation methodologies (in contrast to e.g. use case and requirements analysis or user-centered design which are extensively described in software development and technology innovation literature (e.g. [19, 85, 181, 122, 121])). When developers and end-users do not share the same (cultural) background and are unfamiliar with each others' context, context analysis should be an explicit task.

3.2.3 *Soft systems methodology*

Soft systems methodology (SSM) is an approach used for management of organizational change. It uses organizational process modeling and business process modeling. It is widely used in domains such as business, health care and education, but has not yet been applied in international development [60].

SSM is an adaptive approach that takes action to improve a real world situation. It uses a process of inquiry and social learning to tackle problematical, messy situations which are characteristic for complex, dynamic environments [61].

SSM shows that the outcomes of a change process depend upon interrelated factors, e.g. (i) the people who carry out the investigation, (ii) the perception of the situation at hand, (iii) the methodology used in the change process. This interrelationship of factors requires flexibility and adaptability, to cope with inherent open-endedness and uncertainty of the change process [61].

SSM differs largely from linear methods (such as e.g. logical framework approach, theory of change) that are used to implement change in e.g. ICT4D and other types

of development interventions. SSM is in fact a technically oriented implementation of Action Research. It draws from the tradition of real-world problem-solving social sciences research [16, 61].

3.2.4 *The concept of "ba"*

From another domain of organizational management, the Japanese concept of *"ba"* can be a useful framework for collaborative innovation projects. This concept, originally proposed by the Japanese philosopher Kitaro Nishida, [212, 213], can be translated as "place" or "space". It has been elaborated into a model for knowledge creation and knowledge management in organizations. According to this model, "knowledge" is embedded in a shared space, where relationships emerge. This space can be physical, virtual or mental. Nonaka describes ba as a *"frame, made up by the borders of space and time, in which knowledge is activated as a resource for creativity"*. The inherent dynamics of knowledge as a social process is reflected in the idea that knowledge should be *"nurtured, supported, enhanced and cared for"* [213]. The concept of ba places emphasis on the social and communicative aspects of innovation and knowledge sharing, and on "meaning" in e.g. organizational culture. This could be a source of inspiration for a collaborative type of ICT4D.

3.3 PARTICIPATORY PARADIGMS AND VALUE-DRIVEN RESEARCH

If ICT4D wants to do justice to perceptions, values and interests of people that directly matter, i.e. the supposed beneficiaries, it must take a position in the debate about interests and values. There are various research methodologies which are reflective and value-driven, that can provide inspiration to shape an inclusive and truly participatory approach to ICT4D. Given the interdisciplinary and goal-oriented nature of ICT4D, we will review a number of value-driven methodologies and ideas in the following sections.

3.3.1 *Participatory approaches*

Dissatisfaction with the conventional methods in development projects (in which goals are set by external agents, and transfer-of-technology[5] is common practice) is not a recent phenomenon. In rural development this triggered critical practitioners and researchers to develop new, participatory approaches, long before ICT4D entered the stage (e.g. [47, 254, 43]).

In 1983, Robert Chambers published his book "Rural Development: Putting the Last First" [47], in which he polemically showed how "outsiders", i.e. development

5 In rural development these are for example improved seed, pesticides and fertilizers [251].

experts, NGO staff, researchers, donor agents and other stakeholders misunderstand local needs and context, by failing to take the grassroots perspective.

Chambers called for a paradigm shift in development, towards a more people-centered approach. People-centered and grassroots alternatives, which are referred to as "livelihood approaches" [286, 287] and farmer innovation [251] gained momentum as a new "people paradigm" by putting people first in words and actions [50, 47]. As a practical implementation of this way of thinking, new participatory approaches were introduced.

3.3.1.1 *Participatory Rural Appraisal*

Participatory Rural Appraisal (PRA) comprises various decentralized, open decision-making systems' approaches and methods. PRA enables local people in poor rural environments to plan, act, and share knowledge about their own lives and conditions, in order to enhance their own livelihoods [48]. While formerly information was elicited and extracted by outsiders, e.g. through rigid, closed-question surveys, PRA uses focus group discussions and semi-structured interviews, mapping and modeling, transect walks, matrix scoring, seasonal calendars, trend and change analysis, well-being and wealth ranking and grouping, and analytical diagramming [48].

PRA is increasingly being used in various sectors of international development, including natural resources management, agriculture, poverty and social programs, and health and food security. Participatory evaluation, and assessment of self-perceived success by local communities [249, 251] have proven useful to assess the relevance of action during project execution, and to provide information to adjust project plans when needed. These methods are fundamentally different from the mainstream approaches that consist of "giving instructions to farmers" [48, 50].

3.3.1.2 *Participatory Technology Development*

Participatory Technology Development (PTD) stems from a similar tradition as PRA. PTD goes a step further, by, not only involving local beneficiaries in agenda-setting and evaluation, but also focusing on (local, indigenous) knowledge sharing and diffusion of local innovations [251].

PTD is a hands-on method, based on intense collaboration between farmers, development agents and researchers. PTD combines and merges skills and knowledge, in order to support local innovation. PTD fosters farmers' experimentation and seeks to try out new ideas while trying to adjust to changing conditions of the dynamic contexts. When linked to a wider network of (action-) researchers and development practitioners, PTD and local farmer innovation have the potential of reaching many people and providing adequate solutions to local problems [251].

3.3.1.3 *Farmer Innovation Methodology*

Farmer Innovation Methodology has been developed in the late 1990s in Africa, in the domains of soil and water conservation to fight desertification. Farmer innovation is still used, although it is not mainstreamed in rural development [70, 251, 248, 69, 202]. The idea of the farmer innovation methodology is to harness innovations and experiences from local farmers and disseminate them to a wider group or community. The methodology consists of various components: identifying and verifying farmer innovators, analyzing their innovations, organizing farmer-to-farmer exchange visits and local study tours, setting up farmer evaluation, stimulating joint experimentation, raising awareness and lobbying, and institutionalizing the farmer innovation approach [251].

An important aspect of this methodology is to educate the "outsiders" in the participatory way of working and thinking, quoting Chris Reij and Ann Waters-Bayer: "*many scientists and extension agents have difficulties in communicating eye-to-eye with farmers. Their conventional training and vision of development through the transfer of modern 'improved' technologies have imbued them with a sense of superiority [...] most of them cannot imagine that they can also learn from (illiterate) farmers*" [251].

3.3.2 *Positive Deviance to speed up innovation*

Another example of a community-centered approach to innovation and evaluation is a method to identify local successes, called "positive deviance". The principle is simple and consists of looking for outliers: people who succeed against all odds. Positive deviance is founded on the premise that innovators exist in any community or group. Working with the same resources as anyone else, the innovator has overcome a problem that still confounds others [225]. Quoting Pascale et al. : *"This individual is an outlier in the statistical sense – an exception, someone whose outcome deviates in a positive way from the norm. In most cases this person does not know he or she is doing anything unusual. Yet once the unique solution is discovered and understood, it can be adopted by the wider community and transform many lives"* [225].

Positive Deviance was first used as a method in the 1970s, in health and malnutrition research in rural regions of Vietnam. It consisted of looking for exceptions and learning from innovative solutions in order to disseminate this knowledge and help others. For example: look for children who were less affected by malnutrition despite the widespread occurrence of malnutrion amongst children in this region, and learn how their mothers had succeeded in coping with the problem.

Quoting the initiators of Positive Deviance: *"As a problem-solving process, this approach requires retraining ourselves to pay attention differently – awakening minds accustomed to overlooking outliers, and cultivating scepticism about the inevitable 'that's just the way it is' .*

Once the concept is grasped, attention to observable exceptions draws us naturally to the 'who', the 'what' and especially the 'how' " [225].

In contrast to the (cause-effect) impact evaluation approaches (that focus on attribution of the observed impacts to the donor-funded intervention, as discussed in Chapter 2), Positive Deviance tries to identify mechanisms for local successes: i.e. positive, observable exceptions, which are not the 'failing norm'. Looking at positive outliers is a way to obtain a better insight in local innovations [225].

3.4 PRAGMATICALLY ADAPTING METHODS TO NOVEL CONTEXT

From the methodologies in this chapter we can learn that – in whatever context, low-tech or high-tech – a key element of true innovation is the dialogue with the real users. Prof. Saa Dittoh, rural economist from the University for Development Studies in Ghana, explained this during a symposium on ICT4D[6]. Researchers and development agencies should take a modest role, not pursuing total control. They should blend with the rural communities and provide constructive interaction.

In our search for a better approach to ICT4D, that meets the requirements of doing justice to values and interests of the supposed beneficiaries, and of coping with realities on-the-ground, we briefly reviewed various methodologies from different disciplines. Next, we will develop an operational synthesis of these approaches, pragmatically adapting them to create an actionable and comprehensive approach to ICT4D. This approach has been developed and improved iteratively, during years of extensive field research in West Africa, in the period 2009 – 2017, and has been validated by users – local stakeholders, farmers, men, women, local partners in rural and urban regions of West Africa.

The methods and frameworks described in this chapter are not meant as blueprints for a new type of ICT4D, but as a source of inspiration for people who want to develop new ICT4D solutions. The methods can be re-used, re-invented, adjusted and re-applied. The most important success factors are collaboration between all participants – researchers, developers, users, local and non-local stakeholders – knowledge sharing, adaptation to context, and a flexible, open, learning-by-doing attitude.

This is, as Saa Dittoh describes, the *plug-in principle*: applying adaptive management and collaboration to jointly improve a situation. Quoting Saa Dittoh:

> *"... scientific knowledge cannot replace indigenous knowledge. Thus scientists are at best bettering agents, not change agents. In order to plug-in a certain technology or idea, the interventionist has to understand the existing situation thoroughly and respect the members and existing knowledge within the community. If you think you have a better solution, try*

6 This was said during a keynote speech at the Third International Symposium Perspectives on ICT4D, 6 April 2016, at VU Amsterdam.

first to understand the existing situation. Do not judge too fast. There is a reason why a situation is as it is[7]*".*

In the next part of this book a collaborative, adaptive, and iterative approach to ICT4D is discussed. We have pragmatically adapted the methods described in this chapter, to build this approach that covers the full lifecycle of software development, including context analysis, needs assessment and collaborative goal construction, use case and (business&technical) requirements analysis, sustainability analysis & business modeling, building, testing, deploying and evaluating. It is illustrated with examples and cases from the field.

7 Prof. Saa Dittoh has over 30 years of field experience working with African rural communities and the rural context, and also with development agencies and projects.

Part II

CONSTRUCTING OPERATIONAL SOLUTIONS

[in which a framework for ICT4D is constructed in five chapters. The framework covers the full life cycle of information systems engineering. The approach is collaborative, iterative and adaptive and consists of five elements: (i) context analysis (ii) needs assessment (iii) use case and requirements analysis (iv) engineering, deploying, evaluating (v) sustainability assessment]

4

UNDERSTANDING CONTEXT

When developing ICT services in a low resource environment, ICT developers will deal with situations where the context is largely unknown to them. Therefore, the developers team should take considerable time to become familiar with the context where the envisaged end-users live. Context has various scales: the regional, the local, the human scale. By observing how factors at different levels (or scales) interact and influence each other, the ICT developers obtain (i) specific information that relates to the envisaged ICT development and (ii) a general insight in the complexity of this specific real world context. This aligns well with the second Principle for Digital Development: Understand the Existing Eco-system[1].

4.1 WHAT IS CONTEXT?

Because there is usually a big gap between technologists (ICT developers, researchers etc.) and the world of the end-user, this chapter stresses the need for explicit context analysis. "Context" in this chapter refers to the livelihood of rural communities, in the extended sense as described by Scoones [287].

In the following sections, we will describe how the technologists become familiar with context, why this is important and what can be expected. The ICT developer wants to answer questions which are of concern for ICT (e.g. do people have electricity?) and for a more general understanding (e.g. what do people do for a living?) This chapter presents examples from our own field research, in a setting of regreening initiatives in the Sahel. It introduces a rural context in Africa and describes it at various scales. It does not claim to give a full historical account of the region, but gives patchy information, jumping freely from the regional scale to the local and human scales, back and forth. It gives meta-information and comments why this is relevant for ICT4D. At the end of this chapter, as a concrete outcome for the ICT4D developer, a number of relevant concerns is listed, which should be addressed.

4.2 FIELD VISITS TO RURAL REGIONS OF THE SAHEL

In the framework of the interdisciplinary research program W4RA, the "Web alliance for Regreening in Africa", a team of researchers started a field work program in the Sahel in West Africa to find out if, and how, ICTs – despite local constraints of a low-resource environment – can be made useful for local communities. The researchers'

1 https://digitalprinciples.org/, (accessed 31-07-2019)

team was introduced by local organizations to rural communities in Mali, Burkina Faso and Ghana.

During the visits the team had the opportunity to become familiar with the local (poor, rural) context. We asked local people if they would be interested in having ICTs (services); if people would like to improve knowledge sharing; we analysed the local conditions for deploying ICT services here; we tried to understand the major constraints. During the field trip in September 2009 the W4RA team visited several farmers in the field (See Figure 8). Ranawa, a rural community of 2300 inhabitants, in the Yatenga region of Burkina Faso was visited. This I wrote in my field report:

> *"There is no electricity in this village. People in Ranawa live from subsistence farming and produce millet, sorghum, sesame and have some livestock. The inhabitants of the village of Ranawa have been very successful in applying innovative regreening techniques on their fields, which has increased their crops. We started our visit by a walk through the fields, to see the crops in between the upcoming trees. Our team was introduced to the villagers of Ranawa by our local partner, Mathieu Ouedraogo (president of the local NGO Réseau MARP). We did a focus group with the chief and twelve villagers, while sitting under a tree, next to the village. Translations were made simultaneously by our local partner between the local language Mooré and French. We learned that here in Ranawa up to 98 percent of households use mobile phones for social interaction and business, e.g. to ask for market prices in town, to negotiate with potential customers. We learned that about 1.000 - 5.000 fCFA (about 2 - 10 euros) is spent on average per person per month on mobile airtime. Some people in the village earn money by selling airtime (telephone units) in small units. Since there is no electricity, phones are charged using a motor cycle battery (a phone charging business). The Ranawa community estimates mobile telephony essential. The villagers are open to innovations and curious about new systems of communication and access to relevant information. We noticed an interested attitude towards new technologies. Extra costs are said to be acceptable, but only if the new technologies bring real advantages."*

This is a trip report describing one of our first field visits. Other trip reports containing context analyses for the W4RA program are described by Nana Baah Gyan [130].

4.3 REGIONAL CONTEXT: SOIL DEGRADATION IN THE SAHEL

This section discusses one of the important problems that affect food security in the Sahel. We learn about the development interventions that have taken place to improve environmental conditions and increase food security. We learn about bottom-up initiatives of local communities that have emerged as a reaction to failing interventions. We observe how regional patterns affect the human scale.

Figure 8: A context analysis visit to Ranawa village, Burkina Faso, September 2009. Photo by the author.

4.3.1 *Degrading landscapes in the Sahel of West Africa*

The Sahel is a climatic zone, rimming the southern part of the Sahara desert, stretching east-west across the African continent from the Atlantic Ocean to the Red Sea. With a population of nearly 50 million people the Sahel transects ten countries in Sub-Sahara Africa, which are amongst the poorest in the world[2]. The majority of people in the Sahel live from rain-fed, subsistence agriculture [69]. Average annual rainfall varies from 250 to 600 mm in the Sahel and is concentrated in a rainy season of 4 to 5 months [300].

The Sahel has recurrently been plagued by droughts and famines. The major droughts occurred in the periods 1910-1914, 1942-1949, 1968-1973 and 1982-1984 [250]. During these periods lack of rain has led to disappearance of livestock and to destruction of cereal crops. This has threatened the livelihoods of millions of people. Currently, the local communities can cope with the environmental situation, but they are vulnerable for the effects of an unpredictable climate and for other natural and economic hazards (locust plagues, diseases, floods, price fluctuations of commodities, etc).

In the Sahel of West Africa, soil degradation, progressive loss of vegetation, falling ground water levels and low cereal yields are factors of concern for the inhabitants [304, 250]. Since the early twentieth century until present day, interventions have been undertaken for soil and water conservation in the Sahel. The approaches and the opinions how to do this have changed over the years, and are still being debated [137, 300, 248].

2 Senegal, Mauretania, Mali, Burkina Faso, Niger, Nigeria, Chad, South Sudan, Ethiopia, Eritrea; source: World Bank Indicators 2015.

Since the early 20th century[3] modernization of African agriculture has been promoted, to increase agricultural output and achieve self-sufficiency in terms of food production [203, 193]. Traditional African small-scale farming practices were gradually replaced by larger-scale, western-style agriculture [258, 290, 133]. African farmers were taught by agronomists and national extension services and development experts to clear their fields from vegetation, by periodic cutting and burning. Crops on clean fields were considered more productive than the traditional inter- and double-cropping, which was more labor intensive and looked "messy" [137]. National and regional research institutions were established who did research and focused on varietal improvement and fertilizer application [300]. Cash crops including cotton and cocoa, were promoted and introduced for export [137].

Soil degradation was often blamed by the authorities on overgrazing by pastoralist herds or tree cutting by local communities [137, 18]. To restrict the use of trees and land, forestry law was issued under French colonial administration. This remained in force for years after independence (1960), in Mali, Burkina Faso and Niger [18, 300]. In general, forestry law and policies to protect the natural environment turned out disadvantageous for rural dwellers. Pastoralists were allowed to graze their herds in designated areas only and farmers lost ownership over trees [290].

In Mali and Burkina Faso the Forestry Services who controlled exploitations of forest resources were organized along para-military lines [300]. NGOs, engaged in agroforestry projects, had collaborative relationships with governmental technical extension services and the Forestry Services who were responsible for protection of trees (from theft) [300]. In practice this was devastating for local communities, who received fines for e.g. cutting firewood for the production of charcoal, even on their own fields [18].

The change of land use from traditional to modern agriculture and the removal of the original vegetation caused increased erosion of top soils by wind and rainfall, causing soil degradation and loss of arable lands, over the years [203, 193, 258, 133]. In the 1980s, especially in the longer periods of drought, barren plains, infertile soils, dust storms, severe fodder shortages, and agricultural pest outbreaks were frequent in the Sahel [250, 290]. Disappearance of vegetation led to conflicts between sedentary farmers and pastoralists [290]. Farmers had to expand farming to marginal lands to keep up production for a growing population[4].

4.3.2 *Intervention or participation?*

In colonial and early post-colonial years (before the 1980s) rural development was focused on technical aspects of implementation [248]. Participation of local communities in decision making or in project implementation was not a common practice [203, 193].

3 In Francophone West Africa the colonial period was between 1880 – 1960.

4 The Sahel region has a population growth of 2,7% per year [249]. Over a period of decades this reinforced the trends of land degradation and desertification [250].

In the 1960 and 1970, when droughts led to widespread food shortages, a wave of interventions was launched by development agencies and governmental agencies. The goal was to rehabilitate productive capacity of soils, through control of rainfall and runoff, improved soil fertility management and reforestation. In the Central Plateau of Burkina Faso, a region severely affected by drought, water harvesting structures such as stone bunds, dikes, and dams were built to prevent erosion by surface water run-off during the rainy seasons [248]. These projects were rolled out without participation in decision-making by local communities [203, 193]. (An illustration of the interventionist approach, see Chapter 2.)

Over time it became clear that dikes, dams and stone-bunds were not being maintained by the local population. Lack of communication led to neglecting and sometimes even destruction of the artefacts by local communities [193, 203].

4.3.3 *Interventions that do not serve local goals*

In the 1960s, tree planting projects to fight soil degradation were executed by international NGOs. To "buy in" participation of local communities in tree planting projects, development agencies used paid labor or food-for-work as incentives for the local population [257][5]. A large tree planting project was implemented in this way by CARE International[6] in the Maradi and Tillabery regions of Niger [300].

A case of excluding beneficiaries from decision-making is the story from the Majjia Valley project, rolled out in Niger, in 1967 [300, 46]. This development project aimed at massive tree planting to prevent crop failure from wind and water erosion [46]. The tree species used was *Prosopis juliflora*, an exotic tree that germinates easily and grows fast. The tree was selected by the development agency, despite being strongly disliked by local farmers [46].

Rebecca Butterfield studied this project in 1996, and reported from interviews with local communities: "Farmers reported to have a love-hate feeling towards the species [i.e. Prosopis juliflora], with the majority of people reporting a strong dislike. Translations of common names given to the tree explain why: 'viper', 'bastard thorn,' and 'dangerous thorn' (shejain kawa, mugun kawa in Hausa language). Thorn pricks are painful, causing hands and limbs to swell. One unfortunate farmer who stepped on a thorn, was said to have developed gangrene and died." [46].

In a working paper (1994) about rural development in Mali, the American agency USAID admits: *'By the late 1980s donors and increasingly the Malian Government recognized that block plantation woodlots in villages did not work. Much debate took place on how to increase participation of the population in forestry and natural resource programs'* [99].

5 This was done to recruit local people and pay them *in natura* [69].

6 E.g. CARE did many agro-forestry projects in Niger in 1960-1990s [300].

4.3.4 *Participation or still intervention?*

While participation in post-colonial times was common practice, in the late 1980s – 1990s a new development discourse emerged, in favor of participation and community-centered approaches [248]. This was induced by several trends, debates and publications[7] which showed the effectiveness and necessity of participation in rural development (e.g. [330, 55, 248]). The top-down, interventionist attitude was blamed for frequent failure [300, 258, 18, 258].

A recent example of how a large-scale intervention fails, is the Great Green Wall. This recent continent-scale intervention aims to improve the environment in the Sahel, and fight soil degradation by massively planting of trees[8].

In 2007 the Global Environment Facility (GEF) has commissioned the Great Green Wall program to fight desertification and land degradation in the Sahel. It plans to realize a 7700 km tree belt stretching the length of the Sahara Desert, in 11 countries (Senegal, Mauritania, Mali, Burkina Faso, Ghana, Togo, Benin, Niger, Chad, Sudan, Ethiopia). The program, with a budget of 2 billion US$, is financed by the World Bank, the Global Environment Facility, the Least Development Countries Fund and the Spatial Climate Change Fund[9].

Proposed by the African Union in 2007, the Great Green Wall aims to be the largest artefact on the planet and restore 50 million hectare of degraded land to provide food security to 20 million people, create 350.000 jobs and sequester 250 millions of tons of carbon[10]. Tree planting has started in Senegal and uses soldiers and students as labor for planting activities.

In spite of high investments and expectations, survival rates of planted trees have been disappointing. Field studies of the Great Green Wall reported a 20 % survival rate for planted trees within two months after planting[11]. Concerns exist about sustainability of the project and the maintenance of the trees after the project period. As local farmers do not own the trees, it is unclear who will care for protection of the trees[12].

Notwithstanding a change in discourse and much rhetoric about participation, the tendency of the international community to pursue large-scale ambitions and centrally planned top-down interventions has remained until present day in (rural) development.

7 e.g. Robert Chambers' book 'Rural Development: Putting the Last First' [47].
8 Source: UNCCD.
9 Source: http://www.greatgreenwallinitiative (accessed 31-07-2019)
10 Source: http://edition.cnn.com/2016/09/22/africa/great-green-wall-sahara/ (accessed 31-07-2019)
11 Source: http://tinyurl.com/dead-baby-trees (accessed 31-07-2019)
12 Pers. comm. Chris Reij, World Resources Institute, Washington, USA, 18-11-2016.

Figure 9: Map of West-Africa showing areas of emergent regreening: 1 = Seno planes in Mali, 2 = Central plateau in Burkina Faso, 3 = North of Niamey, 4 = Maradi, 5 = Zinder, 6 = Senegal. Courtesy of Chris Reij

4.3.5 *Strength of local initiatives*

Independent of the Development Debate about participation, a new trend emerged in the early and mid-1980s that opened avenues for food security in (African) drylands. It was *regreening*, a large-scale phenomenon which can be explained as "many trees on farmland" [251, 252, 327, 290, 249]. Regreening[13] is the consequence of change in land-use by rural communities or local farmers-innovators who experiment, invent new agricultural practices and/or re-introduce traditional ones [252, 257]. One of these practices is 'farmer-managed natural regeneration' (FMNR), a set of inexpensive manual techniques that can help increase the number of trees on farmland [252].

Regreening occurs in regions with variable rainfall and frequent droughts and is particularly beneficial for rain-fed agriculture, in areas threatened by soil degradation [327]. Regreening is gradually spreading to drylands of Burkina Faso, Ethiopia, Mali, Niger, Malawi [251, 252, 69, 327]. Regreening improves resilience of local livelihoods through better crops and availability of tree products throughout the year [252, 69]. According to various studies on soil and water conservation in rural Africa, (e.g. [251, 252, 327]), regreening is leading to a transformation of the environment, restoration of degraded soils and increased crop productivity. Regreening can be observed in landscapes as a large-scale emerging pattern from distributed actions by many farmers [252]. A map with areas of regreening in the West African Sahel is shown in Figure 9.

In February 2006, when Chris Reij and Gray Tappan, two agro-environmental researchers[14] travelled through the countryside of Niger to study the local environment and the state of soil degradation and desertification, they observed a vast area of farm land with trees in the region between Zinder and Maradi, in the south-east of Niger. This is a zone of high population density, up to 100 inhabitants per km^2. Remote sensing studies from the US Geological Survey revealed that 5.000.000 hectare of farm land had been *regreened* by the local population [253]. Tree density appeared to be 15 to 25 times larger in 2006 than tree densities recorded in 1975 in the same regions (see Figure 10), amounting to 200.000.000 trees [253, 250]. The scale and impact of regreening in Niger had remained unreported until 2005, despite many interventions and monitoring & evaluation studies from the previous decades [253, 250].

These new agro-forestry systems impacted 1.250.000 rural households in the Zinder-Maradi region. There was an average increase in crop yields of 100 kg per hectare [250]. The impact was an estimated total production of 500.000 tons of cereals per year, providing food for about 4.5 million people [250]. Trees, tree products, better crops and healthier livestock enabled farmers to produce for local markets and provide food for a growing population [155, 249]. Regreening in Niger is seen as one of the largest recent agro-environmental transformations in West Africa [250].

13 Regreening is often referred to as agro-forestry.

14 Pers com. Chris Reij (VU Amsterdam) and Gray Tappan (US Geological Survey); reported at the Program on the Global Environment Inaugural Conference, University of Chicago, May 2008.

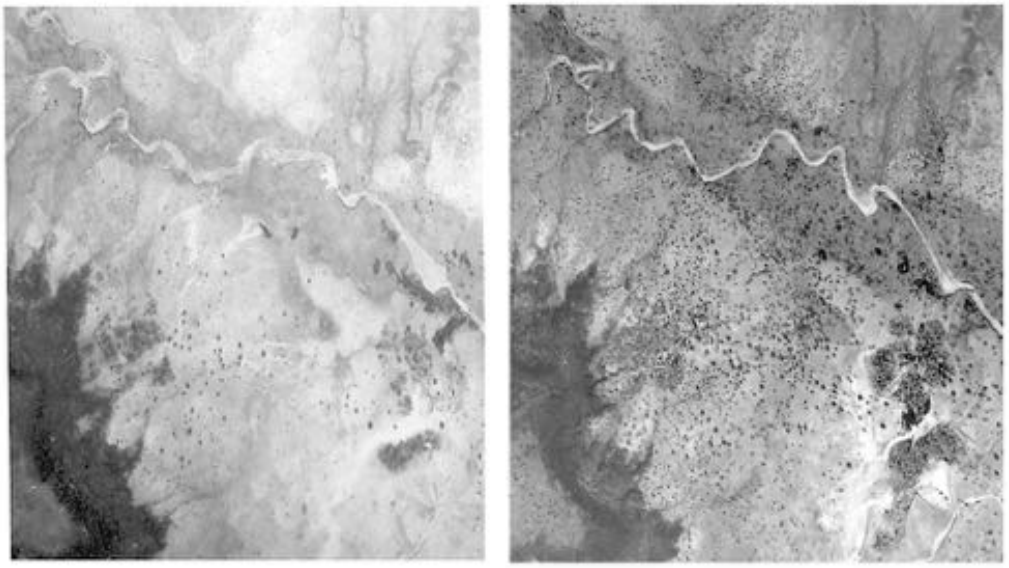

Figure 10: Environmental change in 28 years. Left image shows the village of Galma (Niger) in 1975. Right image shows the same village in 2003. Most of the black dots are mature trees. Satellite image: courtesy Gray Tappan, US Geological Survey, reprinted after Reij & Winterbottom. Scaling up Regreening: Six Steps to Success. World Resources Institute, 2015. [252].

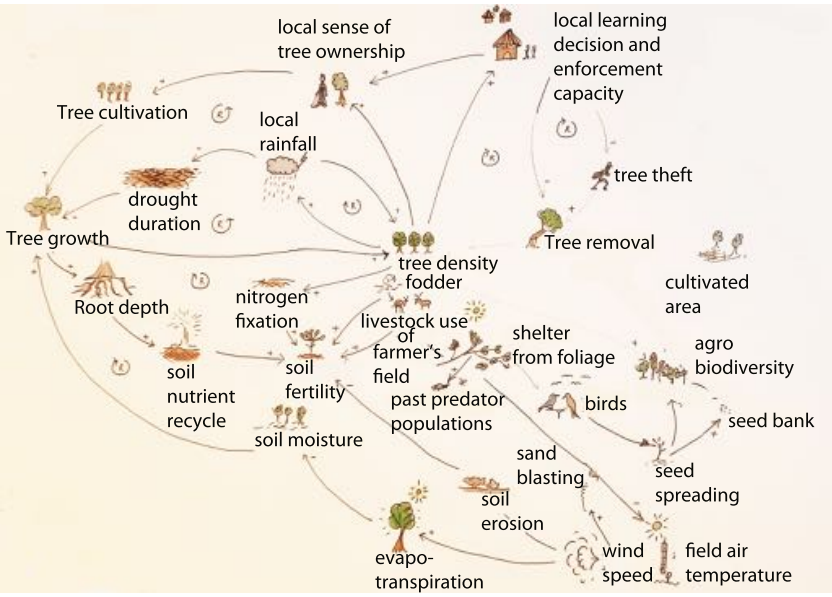

Figure 11: Conceptual model of the variety of interrelated variables that influence large-scale regreening in a complex setting. Adapted after a model by Sendzimir, Reij & Magnuszewski (2011) "Rebuilding Resilience in the Sahel: Regreening in the Maradi and Zinder Regions of Niger" *Ecology and Society* 16 (3): 1, Fig. 5. [290].

Regreening in Niger has been studied from various perspectives. Sendzimir et al. [290]) used conceptual modeling tools and a system approach to map interrelating factors that contribute to regreening in the rural context of the Sahel, as shown in Figure 11. This study combined different types of data: recent remote sensing data, historical data, trends in tree density [290]. Large-scale regreening has been observed in Niger and has been explained as an emerging pattern from many distributed actions and complex interactions [290]. This complexity shows the need to embed development actions and technological innovation in existing processes at various scales (regional, local, human scale).

At about the same period, in the mid-2000s the trend of large-scale regreening was observed in Mali[15]. The widespread emergence of young trees could be attributed to various interrelated factors: change in land-use, adaptation to changing environmental and political contexts and improved collaboration between local communities and supporting practitioners (cf.[253, 250, 290]). In the next paragraphs, a recent history of regreening in Mali is described, as reconstructed from various sources: personal interviews, internal project reports and literature.

15 The information in this section is based on internal reports of AOPP; interviews with Mary Allen Ballo, former *secretaire-executive* of Sahel Eco and the Sahel Eco Annual Report 2005.

4.3.6 *The context of regreening in Mali*

After a coup d'état, in March 1991, the Malian president Moussa Traoré, in power since 1968, was overthrown. A transitional government started the process of policy change and decentralization. In line with international policies, the Malian government withdrew activities and subsidies in rural sectors [304], abolished subsidies for e.g. fertilizers and seeds and stopped its support to local production and trade. This process of policy change had already been encouraged by international development organizations since the 1980s, through structural adjustment programs[16]. The clauses attached to the loans required privatization and reduction of state interference [255].

The effects of decentralization, which have been widely criticized for their negative effects on the social sector [17, 18], were disconcerting for local farmer organizations, who were not prepared for the transition and lacked channels of communication and access to markets. Family farms were heavily affected[17].

Unexpectedly, the policy-led decentralization in Mali also triggered new local initiatives in rural areas including revitalization of traditional village organizations and emergence of community organizations and village authorities [304]. Local organizations were compelled to reorganize themselves and take over the support of (small-scale) production and commercialization in agriculture, livestock and fishery[18]. Despite many problems, the new situation empowered local communities to reclaim ownership of the trees on their fields[19]. This made regreening and agro-forestry a new and feasible value activity for many small-scale farmers [290, 249].

One of the policy changes after 1991, was the revision of ancient forest law in Mali, which was a legacy from colonial times. This law strongly prioritized environmental protection over local agency and farming activities [18]. Based on this law, policy had granted national Forest Service absolute authority over trees. This condition had hampered many regreening activities. National Forest Service agents were authorized to give farmers fines for pruning trees, even on their own lands. The Forest Service had the authority to grant permits (e.g. to urban timber salesmen) to cut trees on farmers' fields. Farmers could not defend themselves against the intruders. The policy changes in 1994 restored the power balance. Local communities were given autonomy to manage trees and practice farmer-managed natural regeneration[20].

The above description illustrates again how various levels/scales are interacting: the national policy is influencing indirectly local agency; the regional scale in turn interacts with the local scale.

16 Structural adjustment programs (SAPs) consist of loans provided by the International Monetary Fund (IMF) and the World Bank (WB) to countries in economic crises.

17 Source: http://tinyurl.com/W4RA-AOPP-rep-pdf (accessed 31-07-2019)

18 See also AOPP Forest Connect Internal Report 2014.

19 Personal communication Mamadou Diatiké, 2016.

20 Personal communication with Mary Allen and Mamadou Diakité.

4.4 CONTEXT ANALYSIS AT LOCAL AND HUMAN SCALES

Having obtained an idea of the issues at regional scale, we (as ICT4D developers) will now zoom into local and human scales. We assess project reports and meet local farmer organizations and national NGOs, and read case studies about the work of local innovators.

4.4.1 *Bottom-up initiatives in Mali*

In the 1990s new bottom-up initiatives, village structures and community organizations emerged, and old ones revitalized in rural Mali. Examples are the (traditional) Alamodiou association, and the new Barahogon association, in the region of Mopti, in the south-east of Mali. In 1995 AOPP (Association des organisations professionnelles paysannes), a local association of professional farmer organizations in Mali, was established as an initiative by local organizations of family farmers to jointly improve livelihoods of local farmers.

AOPP was aware of a decreasing resilience and vulnerability to food shortage among small producers, in the light of the monopolized market system in Mali. This situation was exacerbated by poor communication, wide-spread illiteracy and lack of organization at the village level. AOPP encouraged farmers to use, as an alternative source of income, non-timber forest products (products from trees), as tree products are available throughout the year, including the dry season when there is no harvest. Adding the benefits of trees to soil and water management, regreening became a valuable new endeavor for many rural dwellers[21].

The Barahogon association took the initiative to start regreening on the Seno-plains, an area that was covered by sand dunes as a result of soil degradation. Since the 1990s a long corridor on the Seno-plains had faced serious erosion, soil degradation and the formation of bare sand dunes. In search for solutions to soil degradation, the Barahogon association started to increase the number of trees in this region. This community organization requested local NGOs,[22] to train them in regreening techniques and farmer managed natural regeneration.

Regreening activities were set up and knowledge sharing sessions organized, how to prune trees and clear lands without destroying vegetation. Farmer-to-farmer visits, cross-learning and exchange of indigenous knowledge and practices were part of the collaborative approach by several local and non-local NGOs and the local communities[23].

21 Source: AOPP internal project report: Forest Connect.

22 In the late 1990 SOS Sahel UK, CARE, Oxfam, USAID and various other agencies were active in this region and collaborated with local communities.

23 Personal communication with Mary Allen and Mamadou Diakité.

Bottom-up initiatives by local farmers, sometimes supported by development organizations, resulted in a regreened area of 450.000 hectares[24] on the Seno-plains in Mali[25].

4.4.2 *The effectiveness of adaptive management*

Meanwhile, various local organizations started to set up project activities to make rural communities in Mali aware of their new rights on trees. The first step was to disseminate knowledge to farmers about new tree legislations and about simple affordable techniques how to manage trees. A second step was to create an added value from local non-timber forest products through local transformation and production, financial management and improved communication.

Local farmer organization AOPP[26], promotor of family farming and local self-sufficiency in food production, defended the interests of its members at national level[27].

Sahel Eco, a Malian NGO established in 2005, became involved in training and dissemination on regreening, applying a user-centered, context-sensitive, collaborative approach. Team-building activities were central to Sahel Eco's approach. Farmer-to-farmer visits were organized. Knowledge and experiences were exchanged between farmers.

To make regreening economically viable for farmers, Sahel Eco helped to set up new, so-called *"agroforestry value-chains"*. The activities consisted of (i) training farmers to process/transform tree crops into consumables and (ii) improving local communication to support sales of tree products (commonly called *"NTFP"*, non-timber forest products).

In interviews Sahel Eco staff members told me how they adapted and embedded actions in local culture. For example, there were daily broadcasts on local community radios to disseminate information about new forestry legislation, informing villagers (in their own local language) that tree cutting by intruders was not allowed.

4.4.3 *Meaningful activities and collaborations*

Spread of regreening occurred at various scales: via social networks, personal contacts and mass media (radio was the only one available in rural Mali). The importance of personal communication, face-to-face encounters, testimonials and meaningful collaborations at the human scale was stressed by those involved in activities to support communities.

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24 Source: http://tinyurl.com/Seno-plain-atlas-USGS (accessed 31-07-2019)

25 Recent work by Gray Tappan, US Geological Survey.

26 In 2016 AOPP consisted of 250 local farmer organizations, with 40.000 members, who live from small-scale agro-forestry, livestock and fishery.

27 Source: AOPP internal project report: Forest Connect.

(Here again we make a leap from the general description to the human level of meaning and social interaction.) An example of meaningful dissemination of knowledge about regreening, is the broadcasting of popular songs and poems in local languages on local radio, describing the usefulness of the Balanzan tree, a tree species (*Faidherbia albida*). This tree has many advantages for farming and soil conservation. These poems became famous as they were frequently broadcast in 1995 on community radios in the *cercle* of Bankass, by radio Seno. They made farmers aware of the benefits of regreening[28]. In this poem, written originally in Bambara language by Mamadou Diakité[29] the tree begs the farmer for protection:

> *'Paysan du Séno vient m'aider, soit un espoir pour moi, pour me sauver*
> *Paysan du Séno protège moi contre les dabas*
> *Paysan du Séno protège moi contre les charrues*
> *Paysan du Séno protège moi contre les coups des haches des éleveurs*
> *Paysan du Séno protège moi contre les feux de brousse*
> *Paysan du Séno me sauver n' est pas difficile, il suffit de gratter le sol autour de moi et matérialiser ma présence...'*

A meaningful dissemination action by Sahel Eco is the green "regreening" *pagne*. This cloth (see farmers and NGO staff dressed in green on Figure 12) was awarded to farmers who were regreening champions. The regreening Sahel Eco cloth became famous in the region. Farmer Moussa Sangara was one of the champion farmers-innovators we met in his field, who started practicing regreening in the area of Bandiagara and disseminated this to others in the region of Mali.

Scaling-up and dissemination actions included advocacy films about agro-forestry and regreening. Salif Aly Guindo, President of the Barahogon Association from Ende wrote the following acknowledgement:

> *"Thanks to the production and diffusion of the film about our experience of farmer managed natural regeneration the Barahogon are known today both inside and outside Mali.' [...] 'Although this gives us great feelings of satisfaction we are also aware of the many challenges that we still face including reaching 100% adoption of FMNR[30] in Barahogon member villages[31]".*

Personal testimonials of local successes like the one from the president of Barahogon or the experiences of regreening champion Moussa Sangara are important for diffusion of innovations, through dissemination . AOPP collected a testimonial from Fanta Diamountene, a woman from the rural community of Farakala, in the district of Sikasso.

28 Source: Interview with Mary Allen, February 2016.
29 The former coordinator of the SOS Sahel UK.
30 Farmer-managed natural regeneration.
31 Source:http://tinyurl.com/sahel-eco-Barahogon (accessed 31-07-2019)()

Figure 12: Mali, January 2011: Sahel Eco launched a regreening *pagne*, with the famous "*Reverdir le Sahel*" logo, as a meaningful and team building gift to those concerned with regreening. Photo: Bruno van Moerkerken.

Aged 49, Fanta became producer of non-timber forest products. Formerly, she worked in farming, but due to food insecurity she became interested in tree products. In 2005 she started to collect neré seeds[32] and sell them at the market of Farakala, as a source of income for her family. In 2006, after being trained by AOPP and after the establishment of a new women's union, she started to produce *soumbala*, a staple food transformation of the neré seeds. She managed to sell 50 kg of soumbala per month for 50.000 fCFA, earning 10.000 fCFA (about 15 euro) per month. In 2013 she increased her production to 150 kg per month. This has raised her year income to 450.000 fCFA (675 euro). This enabled her to pay the study fee for her daughter. Fanta is now the president of a local women organization[33].

4.4.4 *Late emerging impacts*

Until late 1990s – early 2000s, the impacts of regreening remained hidden for development experts and researchers despite joint activities to promote farmer-managed natural regeneration by farmer organizations and NGOs. Some projects were considered a failure, because no impact was noticed at the end of the project period. In 2005, almost ten years later, the effects of farmer managed natural regeneration – becoming visi-

32 Neré seed is a tree product.

33 Source: Mady Sidibe personal communication and AOPP internal project report http://tinyurl.com/W4RA-AOPP-valorisation-pdf (accessed 31-07-2019)

ble only after quite some time – were observed, almost by coincidence, by researchers and development agents traveling through the countryside[34]. The area of regreening successes seemed to be expanding autonomously from community to community. In the same period (mid-2000s) regreening successes from Niger and Burkina Faso were published [257, 247, 249] and connections were made between several stakeholders (farmers, researchers, NGOs) in these countries[35].

4.4.5 *Case: farmer innovation in Burkina Faso*

In the mid-1980s regreening started in the Central Plateau of Burkina Faso [249]. This change in land-use was triggered by a period of crises in the 1970s and early 1980s, when the Sahel was struck by droughts [249, 250]. During these years harvests failed, cattle died and food ran short [155]. Vegetation disappeared from the fields and wells fell dry. Trees were cut and sold as firewood – for many a last source of income [155, 249]. Subsequent years of low rainfall had devastating consequences for the rural population. Famine made people – especially the male population – migrate to neighboring countries, in search for paid labour. Women, children and elderly people stayed behind [199].

Despite the lack of food, water and resources, a number of farmers in the Yatenga area in Burkina Faso decided to stay and struggle for change [155]. Yacouba Sawadogo, a farmer from the village Gourga, in the Yatenga province, was one of them. Yacouba Sawadogo experimented with zaï, a traditional practice of manually digging pits in the rock-hard barren soil and filling them with manure, to improve soil fertility and infiltration of rain water[36] (see Figure 13). The method proved successful and Yacouba started to disseminate his knowledge to other farmers in the region. Yacouba Sawadogo became one of the key-innovators and established an association for the promotion of zaï and organized a so-called zaï forum every year, where farmers could share experiences and knowledge [155, 251].

Another farmer-innovator was Ousséni Zoromé, from Somyaga, a village near Ouahigouya, also in the Yatenga province. Ousséni Zoromé also applied zaï and protected sprouts and bushes on his fields, so that they would become trees [155]. He laid stone bunds to improve water infiltration and prevent soil erosion. Ousséni Zoromé increased the number of trees on his land from 9 to 2000 in twenty years[37]. He also created a zaï school, and trained 1000 farmers to restore degraded lands [251, 155]. The knowledge exchange between farmers occurred mainly through face-to-face communication, because of the wide-spread illiteracy [249].

34 Interviews with Mary Allen, former executive secretary of Sahel Eco.
35 Niger, Burkina Faso, Mali, but also northern Ghana.
36 Personal communication with Yacouba Sawadogo, January 2011.
37 Personal communication with Ousséni Zoromé , January and July 2014, February 2017.

Figure 13: Left: Innovator Yacouba Sawadogo practicing zaï by hand, middle: Yacouba in his regreened field; right: a field recently elaborated with zaï and stone bunds. Field visit to Ouahigouya, september 2009. Photos by the author.

Various studies demonstrated the usefulness of simple and affordable techniques[38] for soil and water conservation, and showed how these practices were widely being implemented, often without external support or donor funding [253, 250, 84]. Farmer-managed natural regeneration (FMNG) was an example of innovation and re-invention of traditional knowledge by farmers.

Farmer-led innovations spurred changes in land-use and intensified collaboration between farmers, herders, practitioners, researchers and government agencies, and NGOs[39] [69, 251]. Farmers and pastoralists, who previously disputed land-use, managed to jointly set up combined agro-forestry systems, involving interaction of cattle, manure, soil fertility and trees. Local non-governmental organizations (NGOs) supported bottom-up identification and dissemination of community innovations [290, 249]. Meanwhile other distributed actions contributed to the improvement of local livelihoods [290]. The discovery of ancient tree root systems in the soil, as a potential source for new trees, became of great benefit for local regreening initiatives [257, 252]. Regreening innovations spread accross vast areas. Two decades later, regreening had reached a scale of 200.000 hectares in the Yatenga and Zondoma regions of the Central Plateau of Burkina Faso [250, 252].

4.5 LESSONS LEARNED FROM CONTEXT ANALYSIS

The previous sections have introduced a complex rural context in West Africa at three different levels: (i) at the regional scale, briefly touching on historical backgrounds of soil degradation and food shortages; (ii) at the local scales of communities and farmer organizations; (iii) at the human scale. The last one requires field visits and face to face

38 E.g. planting pits called *tassa* or *zaï* and demi-lunes (semi-circular sand bunds to improve water harvesting) were introduced and disseminated.

39 These projects were a.o. the OXFAM funded agroforestry project PAF, which introduced stone bunds in the Yatenga region, the Dutch PEDI project, the IFAD funded soil and water conservation project in the Sanmatenga, and the German-funded PATECORE project in the Bam region.

meetings. Especially when the ICT developers have a different (e.g. urban, western, technical) cultural background, and are insufficiently familiar with the circumstances of the end-users, as well as the limitations of the environment in which they live. Therefore, context analysis must be done in a systematic way, addressing the regional, local and human scales. This provides understanding that could not have been obtained by e.g. desk studies only.

As made clear in the context analysis in this chapter, the variety of interrelated factors and feed-back loops that exist in a complex context as e.g. the rural Sahel in West Africa (as illustrated in Figure 11) require a realistic and much more refined "theory of change" than the mechanistic intervention and evaluation approaches (e.g. logical framework approach, linear theory of change) that are often used in international development projects, as e.g. described in Chapter 2. We therefore propose context analysis as an explicit and integral part of the adaptive approach.

4.5.1 *Concerns for ICT4D*

Apart from insight in the context, this analysis also yielded information that is directly relevant for ICT4D. Based on field visits (e.g. [73, 27, 75, 26, 131, 130, 25]) a list of observations and concerns has been set up, related to (i) the specific local conditions, which can be encountered in low-resource environments, and (ii) methods to bridge the cultural gap between the ICT developers and users and their local context. Our most important observations are listed below:

INTEREST BY LOCAL PEOPLE IN ICTS The rural community we visited expressed their interest in new technologies that might help improve their information needs. They told us they would be prepared to pay a small (reasonable) amount for a service, if this would really improve something that they value. This interest of local users was confirmed in many other trips to regions in West Africa.

SIGNIFICANT LEVELS OF LOW-LITERACY In rural regions of the Sahel, as in many developing regions in the world, low-literacy is still widespread, so this has a severe impact on ICT. It restricts the affordances of much available technology (for example, systems using SMS-text messages are out of the question). One of the ways to deal with this is to explicitly take into account the preferred mode of interaction of users, e.g. using voice/speech, in local language.

LOW PURCHASING POWER In developing regions, purchasing power of the intended end-users is relatively low. Therefore, many proposed ICT solutions, even if technically feasible, may not be financially feasible, simply due to customer cost considerations. Hence, ICT4D should support the evaluation of the prospective service, specifically with respect to the purchasing power of end-users.

(UN-)AVAILABILITY OF CRUCIAL TECHNOLOGY AND INFRASTRUCTURE An important constraint is the problematic availability of important infrastructures and technologies. In rural regions an electricity network is commonly not present, while in urban areas outages are a regular phenomenon. As a consequence, internet connection is absent in rural regions, and suffers from high cost and less-than-desirable quality (e.g., needed bandwidth) and reliability in the urban areas. Communication technology, in particular mobile telephony (still mostly feature phones, not smartphones), is widely available, but expensive; in rural regions radio is a popular mass communication medium (more than TV, because of its electricity demands). Also, hosting of ICT services is not always possible or at least very costly. Therefore, during the design process, the developers should keep in mind that service deployment already in the purely technical sense is a real down-to-earth problem, and innovative solutions should be sought.

LACKING UNDERSTANDING OF ICT POSSIBILITIES For many intended end-users, it is the first time that they are exposed to ICT technologies such as Internet and Web. This complicates the ICT requirements elicitation process, and before that, finding an adequate ICT-enabled service in the first place. Therefore, ICT4D should deal with ICT-agnostic end-users, for instance by demonstrating successful ICT services in a recognizable development context, show rapid prototypes and mock-ups, and demonstrations.

LOCAL NEEDS UNKNOWN Information needs of inhabitants of low resource environments may be very different from customer needs in wealthy parts of the world. For example, a reliable weather service, although seen as trivial in an urban environment, would be of great added value to rural communities in the African drylands as it simply does not exist now in any usable and accessible form. Thus, an ICT4D project should explicitly focus on the real needs of the prospective beneficiaries or end-users, with an eye on developing ICT services that really matter to the users.

SUSTAINABILITY CONCERNS As explained above, ICT4D projects often receive donor funding. Such funding is essential to develop and initiate the service. However, many ICT4D services discontinue once donor funding disappears. In such cases, the service is not sustainable.

During ICT4D service development, a clear understanding should be created concerning financial sustainability. Typical questions that emerge are: What is the delivery and maintenance structure of the service after the piloting phase? Can the service survive in the longer run by end-user fees or other ways of cost recovering?

MISMATCH BETWEEN DONOR'S AND BENEFICIARIES' GOALS In practice, many ICT4D projects receive donor funding (e.g. from the EU, the World Bank, or large

philanthropic funds such as the Bill & Melinda Gates Foundation) to increase access to and use of ICT in developing countries. There is no convincing reason to assume that donor agency goals will match those of the supposed beneficiaries living in another part of the world.

4.5.2 *Context analysis is key for ICT4D*

Context analysis is not a one-off activity as we will show in the next chapters. It is a recurrent activity, in which understanding of the context is gradually increased. It is important to note that the context analysis should be independent of ICTs going to be deployed or not. The analysis' outcome might even be that no ICT solution is desirable, possible, or suitable[40].

This chapter has shown that context analysis is a key element of a collaborative, adaptive, iterative approach to ICT4D. We argue that context analysis should be an explicit activity in any development action that aims to improve a complex, real world situation. This is necessary because context analysis provides (i) understanding of an on-the-ground validated "theory of change" and its complexities in general; (ii) relatedly, it yields a set of key concerns that need to be addressed.

40 A mistake often made in ICT4D and technology development in general is to jump into conclusions about the need for technology, prior to an in-depth context and needs analysis.

5

NEEDS ASSESSMENT AND COLLABORATIVE GOAL CONSTRUCTION

Needs assessment is a fundamental component of a collaborative approach to ICT4D. It consists of two iterative steps. The first is getting to know what the envisaged users' operational goals are, which information they need to achieve these goals and what their current constraints are. We can describe this step as elicitation and definition of the problem space. The second step is about exploring the solution space, setting priorities what can and should be done. The result of the first iteration is a list of needs and priorities, as expressed by the end-users. The second iteration yields a long-list of project ideas or a portfolio of key ideas for ICT4D. The process of needs assessment involves extensive two-way knowledge sharing and collaborative decision making. This shows how the first Principle for Digital Development: Design with the User[1] can be made operational.

5.1 AN ITERATIVE APPROACH TO GOALS AND NEEDS

This chapter describes a methodology for collaborative and iterative needs assessment in ICT4D. Firstly it describes how the problem space is explored during face-to-face meetings with representative users. Secondly it shows how the solution space is explored and how this leads to a list of project ideas which can be elaborated (at a later stage) into ICT systems/services/solutions.

The first iteration is getting to know the users' own needs and objectives and making them explicit. It is not easy to distill one's information needs, especially when a user or user group does not know what ICTs or "information needs" are. Conversely, it is difficult for the ICT4D developer or researcher who is an outsider, to understand the users' operational goals, workflows and activities. To cope with these issues we developed a collaborative, iterative workshop approach, capable of tackling complex, unstructured information.

During the second iteration, after having collected a number of user stories, constraints, problems, possible solutions and business ideas, it is time for selection of key ideas: which ideas are most interesting for the users, balanced against technical and cost considerations. The developers' team must make sure that user expectations are realistic (what can be achieved and what will work), given the constraints of costs, time, feasibility and technical skills.

Needs assessment yields a portfolio of key ideas and user stories which can be analyzed and elaborated into real systems' design. The process can be jointly evaluated

1 See: https://digitalprinciples.org/, (accessed 31-07-2019)

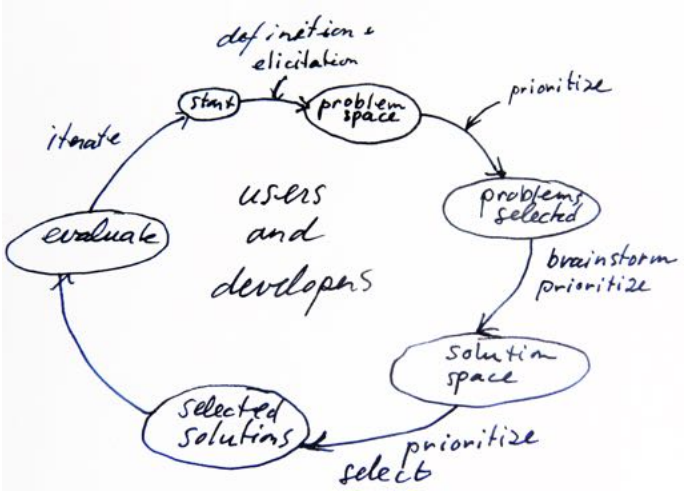

Figure 14: Our proposed model for a collaborative, iterative needs assessment: defining a problem space, a solution space, selecting and evaluating key ideas.

and re-iterated. Collaborative goal constructing and decision making by developers and users remain important, throughout needs assessment. The iterative process is sketched in Figure 14.

The collaborative/iterative needs assessment approach is illustrated in this chapter by examples from workshops by the W4RA[2] research team and local partners, in rural Ghana, Mali and Burkina Faso, in the period 2010 – 2018.

5.2 FIRST ITERATION: JOINTLY EXPLORING THE PROBLEM SPACE

To build useful technologies – in low-resource environments or anywhere else – it is important to bridge the (cultural, physical, language) distance between developers and users. Partnerships, dialogue and mutual trust are essential. Face-to-face meetings and collaborative workshops, preferably in the users' own environment, must be organized. Representative sites must be visited. Developers learn what users perceive as needs, problems and opportunities. To encourage creative thinking, technology demos or short videos are shown.

Needs assessment requires extensive information analysis techniques: focus group discussions, group assignments, field visits, technology demos (see Chapter 3), and portfolio building. Some techniques are borrowed from existing methods: living labs, which are innovation spaces where developers and users jointly innovate [19, 6]; soft systems methodology, for assessing and conceptually modeling users' needs [61]; the Japanese concept of 'ba' [213, 215], for establishing creative spaces of innovation and dialogue; various elements of participatory technology development (PTD) from African

2 https://w4ra.org

farmer innovation are applied [251]. The following list of generalizations are based on my experience obtained during fieldwork in the period 2009 -2018.

ROADSHOWS Our research in West Africa involves roadshows to farmers in the field, living in small rural villages. Meetings with key users take place in open spaces, under a tree, in the users' own environment. Commonly, a field visit to a rural community takes 2-3 hours, starting with a courtesy visit to the village chief, followed by focus group discussions with a group of people. These meetings are chaired by a local contact-person (a local NGO or university staff member). The contact person makes the international team aware of local protocols.

TALKING WITH USERS To avoid communication gaps, it is important that developers talk with envisaged end-users themselves, not just with intermediaries (NGO people, local experts, governmental agents). Whereas these intermediaries may be sources of (contextual) information, they do not replace the dialogue with the real end-users. ICT developers may be tempted (for various reasons, e.g. to save costs or time) to talk with intermediaries only. However, this will not reveal the full picture of needs and requirements, and will not lead to a good (ICT) solution.

ROLE OF THE MODERATOR: The workshop moderator/requirement engineer mediates between users and developers and poses *what if* and *how is this done* questions: What if the actual constraints can be solved using innovative technologies? How do the users themselves perceive the problem(s)? Are problems related to lack of information and/or difficulties in communication? For which reason would potential users value a certain (technological) solution. Are there alternatives? How do things work currently? Who are the stakeholders/responsible persons in the given process? What will be improved by building a new ICT solution? What should or could be improved? What could possibly go wrong?

LOCAL ENVIRONMENT: Field visits are useful for the ICT developers – who are often unfamiliar with rural contexts – to observe and experience how things are done in practice. Users may not be used to describe how they perform tasks or work, so it is useful to observe them while performing. Talks during field visits trigger discussions between developers and users and lead to new questions and answers.

TESTIMONIALS OF OTHER USERS: Local users who have previously participated in a similar project, are invited to share their experiences. The explanation is better understood when told by peers.

EXPERT INTERVIEWS: Interviewing a (local) domain expert is a method for elicitation of specific domain knowledge and understand how local work flows are or-

ganized. In a complex new context, the interviewer must take an open attitude, and realize that she does not know what she does not know. She asks many "what if" and "how" questions. Interviews are semi-structured and preferably done with more than one interviewer, to capture as much information as possible. Sometimes a translator is needed, if the interviewee speaks only a local language. Interviews are recorded and filmed and written out in field notebooks. Photographs are made, (with consent from the users). Conceptual models or mind maps are used to visualize the structure of the interview, see e.g. Figure 19.

BUSINESS IDEAS AND STAKEHOLDERS: Taking into account the future sustainability of possible ICT solutions, business ideas are assessed, which relate to the users' operational goals: their work or business. Participation of local (potential) business partners is an essential aspect of the needs assessment, to understand the local ecosystems in which ICT4D services are supposed to be deployed. Business partners can be e.g. local radio stations, veterinarian services, local ICT business and other local interested stakeholders.

LEGACY SYSTEMS: ICT development (in general) is easier to build and more sustainable when it starts from a 'legacy' system, i.e. an existing information or communication work flow that is already in place. The advantage of legacy systems is that, even if inefficient, they represent a useful and/or meaningful process in the local context. Legacy systems can be paper-based, manual or oral communication of information system, that have a clear work flow. During needs assessment legacy systems and existing work flows are studied in detail by the developers, through interviews with different users of the system.

PROTOTYPES AND TECHNOLOGY DEMOS: ICT demonstrations such as mockups, prototypes, story boards and films show users what ICTs have to offer. In contrast to deploying an application at once, this method ensures that solutions are meaningful for local goals and context. These demos encourage group brainstorming about constraints and ideas for possible solutions.

Rapid protoyping, i.e. building a demo system according to users' ideas during the workshop, is a quick method to increase understanding of the users about ICTs and its development process and encourage brainstorming and evaluate usefulness of an idea. Users can evaluate the prototype immediately and give feedback. This requires the presence during the workshops of skilled technical ICT4D developers. A platform[3] for rapid prototyping in rural conditions (no internet, mobile solutions, high temperature, no electricity) is essential.

3 For example the Kasadaka was developed for this purpose, see: http://kasadaka.com (accessed 31-07-2019)

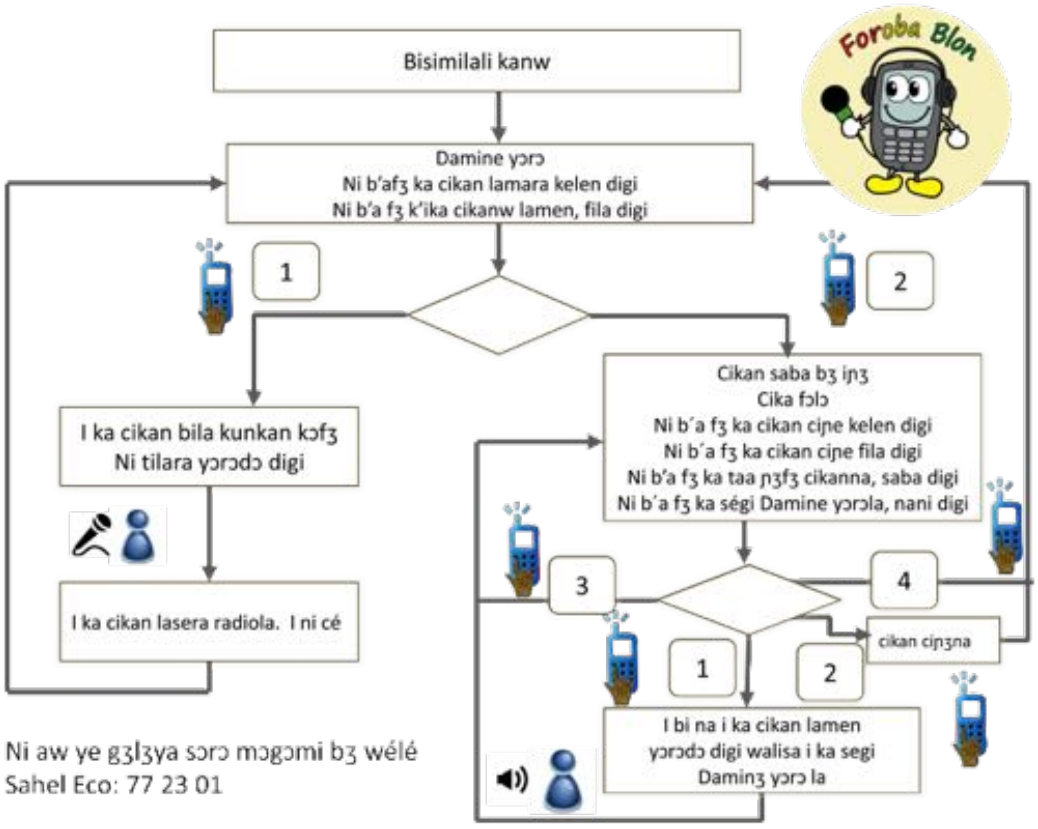

Figure 15: Example of a contextualized call flow model for a mobile voice-based dialogue in Bambara language. This model was used to communicate with end-users about the requirements for a voice-based system. Logo by Victor de Boer; call flow by Anna Bon and Stéphane Boyera; translation by Amadou Tangara.

Contextualization of demos and prototypes is important. As an example, a call flow diagram in Bambara, as shown in Figure 15, was used to explain users how a voice-based application works[4].

FILMS AND PRESENTATIONS: Short (3-5 minute) clips of ICT systems, previously built for similar environments, are shown during workshops to make users aware of the possibilities of context-sensitive software solutions and to encourage brainstorming. Sometimes demonstration is not possible due to a lack of electricity. Ideas and requirements are collected on notes, audio tape and video. Brainstorming sessions are audio-taped and filmed, (with prior consent of all participants). Comprehensive field trip reports[5] are produced.

4 The translation of this text to Bambara was done by one of our partners and key-users, Amadou Tangara.
5 All our trip reports from the period 2009-2017 are available on demand.

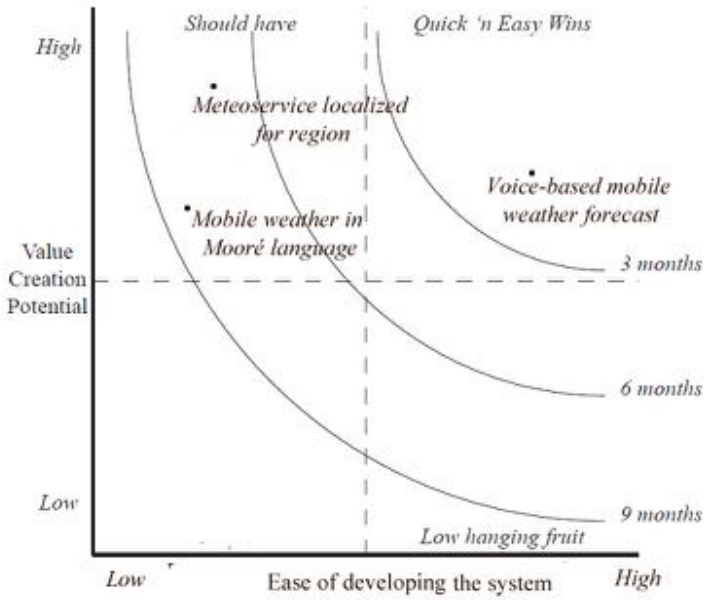

Figure 16: Prioritizing projects based on two criteria: relative value for local users, mapped against relative ease of technical development/deployment. In this diagram a number of project ideas for a meteo service are plotted, relative to the two criteria/axes. Adapted after Amir Hartman, John Sifonis and John Kador (2000) *Net Ready: Strategies for Success in the E-conomy*. NewYork: McGraw-Hill. Copyright: Hartman et al. 2000 [138]

CULTURAL ASPECTS: Field visits often have a ceremonial aspect. During context analysis and needs assessment visit in January 2011 to the village of Tongo-Beo in nothern Ghana, our team leader was offered a goat by the village chief, as a token of appreciation for the work in support of the community. During another visit in January 2011 to the village Yameriga, in Ghana, about 50 women welcomed us with a dance performance. After this ceremony and a village gathering with 150 people, we made a tour in the village and surrounding fields.

In the following sections, needs assessments sessions are described, performed in Ghana, Burkina Faso and Mali. The W4RA team visited various sites in rural Africa to understand the user's objectives, needs and constraints, and collaboratively find out what could be done to improve information sharing and communication, given the (limited) available resources and local constraints.

5.3 SECOND ITERATION: JOINTLY DEFINING THE SOLUTION SPACE

The result of the first iteration needs assessment, described in the previous section, is a list of domains, problems, constraints, ideas. The next iteration is a joint exploration

of the solution space. Selection of key ideas is based on relevance: which problem is considered most pressing by the users? For each of the selected problems a solution space is sought. From the range of solutions, a selection is made. This selection process is done collaboratively, during the workshops.

COLLABORATIVE GOAL CONSTRUCTING Prioritizing and selection of key ideas is based on two types of criteria, firstly: what would be the most advantageous solution for the users; secondly: what would be feasible, given constraining costs and complexity for its technical development added up to the given local constraints (e.g available infrastructure (e.g. no electricity, no internet), local purchasing power of people with very low incomes, and cultural issues such as language and (il-) literacy). We distinguish the following subcriteria: (i) usefulness (i.e. increased efficiency of a certain task or improved communication), (ii) being fully adapted to the local context, (iii) feasibility in cost of use, (iv) simple in use, (v) generalizable and transferable to other regions, (vi) easy/inexpensive to develop and maintain, (vii) interesting in terms of local business or commercial service. The diagram in Figure 16 (from Hartman et al. [138]) can be used to map the different project ideas to see their relative priority according to these two criteria. This method is used by Cisco to prioritize ICT development projects in a high-tech environment, and has also proven useful for ICT4D needs assessment and collaborative goal-construction. In this example in Figure 16, three different project ideas from farmers in Burkina Faso are mapped.

Each of the proposed solutions/key ideas is jointly evaluated against these criteria. This results in a portfolio of user stories, to be further elaborated, designed and built. Evaluation can lead to new ideas or solutions. The process can be re-iterated for improvement. This is conceptually visualized in Figure 14. A more extensive description of structured portfolio selection in ICT4D is given by W4RA team member/colleague Nana Baah Gyan (2016) [130].

The exercise of setting priorities results in a portfolio of use cases that can be further developed. The following sections illustrate how collaborative needs assessment works in the field.

5.4 CASE: NEEDS ASSESSMENT IN GUABULIGA, GHANA

Since 2009, in the framework of the research program W4RA – the Web Alliance for Regreening in Africa – our team has worked, together with a team of researchers from the University for Development Studies (UDS) in Tamale, Ghana, to improve and facilitate knowledge sharing in rural communities in Africa. UDS, which is a public university in Ghana, has the goal to help improve living conditions of people in rural areas, through community-oriented education and research[6]. This is operationalized through the Third Trimester Practical Field Programme in which each student at UDS

6 http://www.uds.edu.gh (accessed 31-07-2019)

Figure 17: Needs assessment workshop with women of the rural community of Guabuliga, Ghana, December 2014. Photo by the author.

has to do a community-based internship and work in a rural community during a certain period of his/her study.

In 2014 and 2015 we teamed up with researchers from UDS for a needs assessment in the Guabuliga rural community in Northern Ghana[7]. This village has about 2000 inhabitants who live from farming and livestock. Despite the fact that UDS does not have an ICT4D department or an ICT4D research program, the approach of UDS to do a needs assessment with local communities is user-centered, and bears similarities to our collaborative ICT4D approach.

5.4.1 *Focus group discussions*

In December 2014, and April 2015, our UDS partners drove us to Guabuliga, near Walewale, in the Northern Region of Ghana. We did two needs assessment workshops with a group of men and women of this community.

The visits to Guabuliga started with a courtesy visit to the village chief. We told the chief about our research and asked him permission to do this workshop. After the visit, focus groups discussions took place at the village square. Four different groups of UDS and VU researchers worked with different members of the community in parallel. One of the group meetings took place in the shade of a mango tree (see Figure 17). In total 130 participants, of which 85 women, participated in the focus groups. Figure 17, and the following paragraph, give an impression of the focus groups. The questions are written in italics, the answers are a summary of all the reactions of the participat-

7 This workshop was funded by Dutch donor agency Nuffic, through the NFP-TMT program.

ing farmers, men and women. The whole session was translated simultaneously from local language Mamprusi to English and vice-versa, by researchers from UDS, who participated in the workshop.

This focus group started with seven women and five men, at the village square named Maasuyiri. After half an hour the numbers grew to about 30 people: 12 men and 18 women. The UDS/VUA team explained the purpose of the visit and the reason for the focus group. Amongst a few other topics, the following was discussed with the villagers : (i) land, water & ecosystems (ii) weather and climate (iii) livestock. (These topics discussed with the community were not set by our team but came up naturally from the group discussions.)

LAND, WATER & ENVIRONMENT AS ECOSYSTEMS: *What have you seen changing in positive or negative sense, in the past 30, 20, 10, 5 years?*

"We have seen loss of soil fertility. The land is increasingly exhausted and as a result, crop yields have significantly declined. This requires that farmers start the application of chemical fertilizer to crops such as maize, soya beans and millet. Moreover, over time the amount of rain has decreased significantly and this adversely affects crop yield and causes food shortages in most parts of the year. (e.g. shea trees are drying up, dawadawa is not fruiting this season and these could exacerbate the problem of food shortage). Most of the observed changes occurred between 6 to 20 years ago."

What are the crops, animals, and wildlife found here?

"There has been much change over the years. Food crops such as zamzam (sesame), adowa, naara (early millet) and sumpea are no longer cultivated. In the past, it was common to find rabbits, antelopes and other wildlife in the bush but today, most of these animals have become rare in the bush. There is literally no more wildlife in the area (they have significantly declined in numbers). Only hedgehogs and rats are still quite common. Bush burning may be the main reason for driving wildlife out of these lands."

What do you produce?

"In the past we cultivated crops like black-eyed peas (supea), zamzam (sesame), naara (early millet), adowa. Nowadays we produce maize, late millet, beans, sorghum, and groundnuts."

WEATHER AND CLIMATE: *What do you see as the important challenges for farmers related to climate and weather?*

"The main challenges are erratic, unpredictable rainfalls, low soil fertility (tired soil) and excessive sunshine."

How do you try to address these problems?

"We leave crop residue on our farms and then plough them back into the soil during the farming season to improve the soil moisture. We use stone bunds to direct the flow of run-off water, and apply contour ploughing. We use manure and compost to im-

prove soil fertility. We make sheds to minimize the consequences of excessive sunshine and rain water for vegetable nurseries, where we grow e.g. pepper and tomatoes."

What kind of weather information would be helpful to address this?

"Daily rainfall forecasts would be useful. Information on rainfall duration in the rainy season – to help farmers in making planning decisions which types of crops to sow/plant, where and when. Information on the severity of wind and its direction is highly needed to help farmers prepare in advance, e.g. reinforcing house roofings, planting trees to serve as windbreaks."

LIVESTOCK: *How beneficial has livestock been to you, and in which ways?*

"Livestock is used in Guabuliga as savings. Livestock can be sold whenever there is a need to diversify sources of income, when there is low food production. Sales of livestock is done to provide an income to buy food, pay school fees, health care insurance, house building, clothing. Other advantages of livestock are: manure on farms, payment of dowry. Cattle, especially bullocks are used to plough on farm land."

What are important problems you face related to livestock?

"Prevalence of animal diseases is increasing, and is currently a major cause of livestock mortality. Unpredictable patterns of disease outbreaks that lead to death are occurring. The known disease cycles/calendar are not applicable anymore. There is a perception that livestock imported from neighboring countries have diseases that infect local breeds. The symptoms are enlarged organs such as heart and lungs. This is a major cause of death of the cattle of Guabuliga. Other challenges in relation to livestock are: there are not enough water points or wells for animals to drink from. As herds have to walk large distances to find water, this increases the risk of livestock theft, especially amongst roaming grazing herds."

What are people doing to address these problems of the livestock?

"Veterinary officers (from Wulugu) are often contacted (via mobile phone) whenever there is an outbreak of disease that affect livestock in the community. Vets provide vaccination services and curative advice. In the past, community members dug ponds to collect and supply drinking water to their livestock. This has stopped because of low rainfall."

What kind of information would help to address these problems?

"Information related to the signs and symptoms of various animal diseases, categorized and sorted would be very helpful. This should include timely information on what to do when an animal shows signs and symptoms of diseases, and information on disease incubation period."

5.4.2 *Interviewing an animal health expert*

To obtain more background knowledge on animal health in rural Ghana, in December 2014 and May 2015, we were introduced by Francis Dittoh, researcher at UDS[8], for an interview to the local public veterinarian service in Tamale, from the Ministry of Agriculture[9], see Figure 18.

We wanted to know if an application to diagnose animal diseases would make sense. We wanted to have more knowledge on how animal health works in this rural context. The author interviewed the vets. The other colleagues took pictures and did the recordings. The interview was done in English. A questionnaire, prepared by students from VU, was the starting point for the interview, but it soon became a semi-structured interview. This interview with the local vet can be seen as a context analysis. This illustrates the iterative character of our approach. The interview was necessary after the need expressed by the Guabuliga community. A concept map of the structure of the information, obtained from the interview, is shown in Figure 19.

The veterinarians we met in Tamale, in the Northern District of Ghana, are traveling vets from a public service. They travel around and visit rural villages in the region around Tamale. We talked to Abubakari Zibuila, technical officer Tamale Veterinary Clinic, Dr. Amoro Nelson Agemga, from Tamale Metro Veterinary Clinic, and Senior Dr. Baba Issah, Zonal Officer in Tamale East, who actually gave most part of the interview[10]. In our interview we focused our questions on the most important animals, cows, goats and sheep.

What is a veterinarian's working day like in Ghana?

"We attend cattle at the community, when a farmer approaches us if an animal is sick. It is too stressful to bring the animal, so we go there when they call us. Sometimes it happens when the animal gives birth. We work from Monday to Saturday, visiting the [rural] communities."

How many veterinarians does each region have on average?

"There are 14 vets in Tamale, working for the Metropolitan Agricultural Development Unit. There are eleven vets in the metropolitan area and three in the outside district."

Which types of animals are taken to the veterinarian?

"Vets treat all kinds of animals: cows, goats, sheep, horses, donkeys, chicken, pigs, birds, fowls, and even dogs, cats and sometimes snakes. All the species you can think of."

What are the common diseases of animals brought to the vet?

8 Francis Dittoh is currently a PhD researcher and colleague in the W4RA team.

9 The meeting took place Thursday 17 December 2015 12:15 – 13.45h.

10 This interview is shortened and revised for readibility. The original is available at request, both on tape and written out.

Figure 18: Visiting the veterinary service in Tamale, Ghana, 17 December 2015.

"If we base on cattle we distinguish the following diseases often reported: Foot and Mouth Disease (FMD). Farmers here are married to poverty, so they do not vaccinate. Some treat with antibiotics. Some do not, by the second or third disease the cattle die. Sometimes it seems to heal by themselves. But then it can spread the disease. Black Leg or Black Water is a bacterial disease. It affects te arm or the high limb. It is acute. It can occur overnight. CBPP (Contagious Bovine Pleuropneumonia) is the third endemic disease here in Ghana. Anthrax is the last one. For now it has not occurred. We have taught the farmers about Anthrax. When they understand it, they agree a date to confine the animal on a certain date for vaccination. The last time we experienced anthrax in Tamale was in 2001. In other regions Anthrax is endemic, and it occurs every year. Since we had a vaccination, every community has to vaccinate. They have to pay for this and we do the vaccination. Sometimes they do not confine [the animals]. You go to the community that has responded. Anthrax is a highly infectious and fatal disease of mammals and humans, is caused by a relatively large spore-forming rectangular shaped bacterium called Bacillus anthracis."

How much does a veterinary consult or surgery cost on average?

"The farmers are married to poverty. They may have 30 cattle but they do not want to pay for a vaccination, until the disaster suddenly occurs at their farm. They do not vaccinate because of the cost. They would like to have free vaccination. Formerly, the Ghanaian government paid for vaccinations, but due to economic motives, they now leave it to the owners. Only the farmers who see the importance, call us and pay for it. The cost of Anthrax [vaccination] is 3 Ghana Cedi[11], for CBPP it is 4 Cedi; for Black Leg is 2 Cedi. The FMD does not have a vaccination; by contact it will spread; you collect the sample from an infected animal; in Ghana there is no vaccine. What we do is, we prevent the spread to other animals in two or three days. The treatment of FMD is with antibiotics, which can cure it. The cost of antibiotics is difficult to estimate, as

11 Cedi or GHS is the Ghanaian currency, 1 GHS is about 0,2 eur.

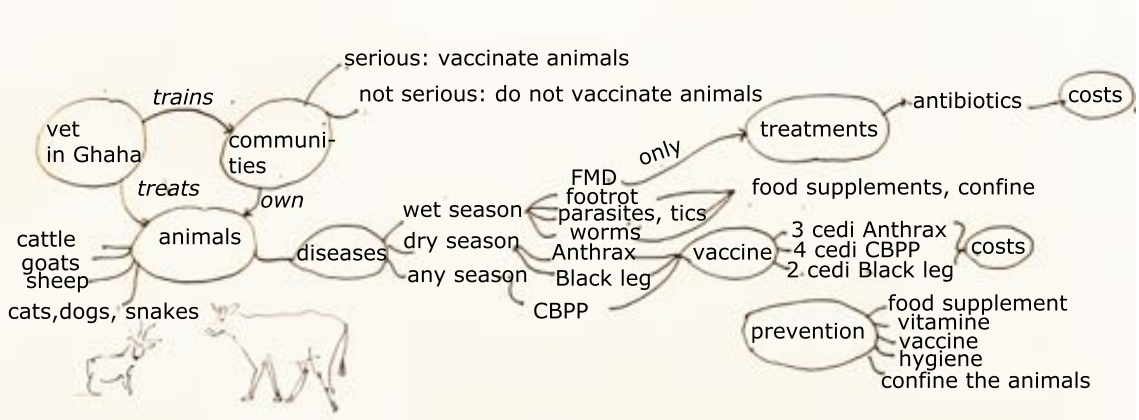

Figure 19: A (field-based) mindmap of the information obtained from the interview with the vet. It shows the important concepts and their relationships, by the author. This model was used to build DigiVet, a decision support system for animal health, by Gossa Lô.

it depends on the body size, on the condition of the cow and sometimes you also need other medicines. We can charge below 5 Cedi, but it can go up to 20 or 40 Cedi. "

What are the diseases that are characteristic of the rainy season/the dry season?

"During the wet season there is FMD, foot rot and parasites, tics on the grasses. Cattle grazes and the tics invade the system of the animal. Tic diseases can break the system. The most contagious of all diseases is FMD, as this can affect any four-legged animals (no birds). During the dry season, in the peak of the heat, Anthrax and black leg are the usual diseases. Animals are grazing closer to the ground. Anthrax can live in the ground 30-40 years. They can also get Tetanus."

How are these diseases treated/prevented in general?

"All the diseases have vaccine, only the FMD does not have vaccine, only antibiotics."

Do you use ICTs, such as computers or cell phones, in order to complete your daily tasks?

"We use mobile to make a picture of a disease snapping with your phone to show the authorities. Our system is so poor, we do not have notebooks. Farmers do not use pictures, they are sometimes illiterate. They can only call you. An animal died so they call us. When they have a situation they want us to come within an hour."

Does the government provide some service or subsidy for vet services?

"Only for fertilizers, but not related to animal health."

Do you use the internet for consulting vet info?

"We do not use ICTs for professional use. Only for personal use."

About goats and sheep: Do farmers vaccinate goats, what diseases do they get?

"Yes, goats are affected by similar diseases as cattle. They can get PPR (*'Peste des Petits ruminants'*), a sheep virus disease, to which we also vaccinate. Sheep and goats can get Black Leg, Foot Rot, Anthrax, basically the same diseases as cattle."

Can farmers easily recognize the diseases?

"We give workshops to farmers. Serious farmers are the ones who care for their cattle and say 'oh it is time to confine and vaccine the animals'. These are the serious farmers. A whole community can be a serious community. They have an interest. The rest of farmers do not do that."

Why do farmers keep cattle?

"For economic benefits. They cannot slaughter themselves. Use the donkeys for ploughing. They apply the manure for the land. Treatment and service is hard for them. The most important thing to teach to farmers is how to know when the animal is healthy or when it is diseased. Some conditions are not diseases, but only [due to] nutritional conditions. Some things can happen when they [the animals] do not get good food. E.g. in the rainy season you see when a calf has worms: it will walk in a wobbly way. So you ask the farmer to confine the animal and de-worm it and give it supplementary food. When animals have Foot Rot you advise them to bring the animal out of a wet area in the rainy season and to take the animal to a dry place so the foot will heal."

"When its immunity goes down, the animal can get other diseases. You can do some prophylactic by boosting their immune system. We give them calcium or multi-vitamin. This is expensive to farmers. Our farmers are married to poverty. They may have 100 animals, but they will say 'I do not have money'. They will categorize it as difficult. We tell them not to plough with [sick] animals, but they refuse. When problems occur they call us. When the rain has reduced they come. Rains start around June until October. We also give them advice about cropping. We say: go to other communities to learn from each other. We train them."

How often do you train the communities?

"Community training is done when you give a vaccination. We do that and we take the opportunity to talk and train."

5.4.3 *Evaluating ideas for ICT4D*

We showed the vets a prototype of the system which is shown in Figure 19. What do you think of this DigiVet system? Would you use the system? Do you think the system would be used when implemented? Can you give us any tips or advice regarding the systems? Could you think of any additional things the system should be able to do? Would you be willing to answer some questions regarding this project in the future?

"Show the farmers the application and they will start using it. A veterinary officer can show it. If they know the condition and diagnose, you do not have to go there anymore. So, it will help them, certainly in combination with the vet officer's visit. Sometimes it is difficult to diagnose a black leg from a snake bite for them. Depending on the number of tablets, we want to do a test with two ot three tablets to see if it works."

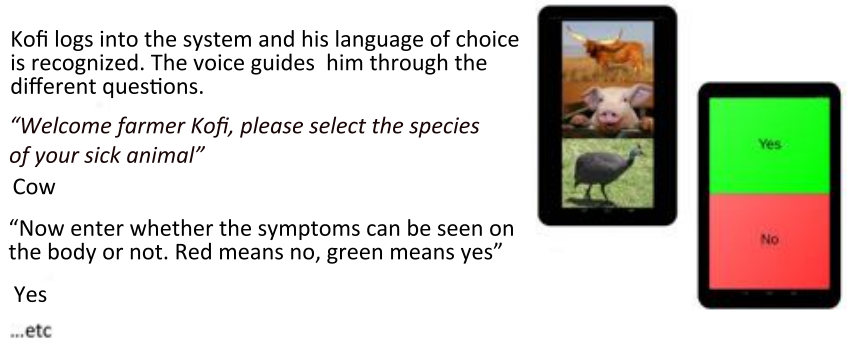

Figure 20: Example of the prototype for DigiVet, a system to diagnose animal health, designed and built by Gossa Lô and Romy Blankendaal.

We will start building a prototype based on your input and them show it to you again. It will not work the first time. It will take months or a year before it works.

5.4.4 *A prototype for animal health diagnosis*

Based on the (first) information collected from the Guabuliga community, and more needs assessments (iteratively) by colleague researchers from the W4RA team, in the community of Zanlerigu[12] in northern Ghana, animal health appeared to be one of the serious concerns in this region.

It was decided to build a simple prototype for a system for animal disease diagnosis. The idea was to enable farmers in rural Ghana to obtain veterinary information about animal diseases based on symptoms of various local diseases. The prototype would be shown to the farmers, in a next visit, to ask them if this would be a useful application. The idea was to make a mobile, voice-based system in the local language Mamprusi, but for demo-purposes a simple demo on a small touch screen (tablet) was used (see Figure 20).

A prototype named DigiVet was designed and built. This was demonstrated during several workshops, including in Mali for AOPP. To improve DigiVet, the students/junior researchers[13] from the W4RA team[14], built a knowledge representation model in 2016[15].

This knowledge model was based on various sources of veterinary expert knowledge, including from the veterinary in Tamale. With the textended DigiVet system, farmers would be able to select from a menu the symptoms of a sick animal. The system provides the user with a possible diagnose, and advises whether or not to contact

12 Gossa Lô and Myrthe van de Wekken did their master research field work in this village.
13 Gossa Lô and Romy Blankendaal, supervised by Stefan Schlobach and Victor de Boer.
14 With a grant from the Network Institute@VU.
15 See http://w4ra.org/wp-content/uploads/2017/05/GossaRomy_Report.pdf (accessed 31-07-2019)

Figure 21: Left: plenary discussions after needs assessment group work; right: demo of digital meteo station by key-user Amadou Tangara, 11 October 2015.

a veterinarian. In this way, DigiVet aims to help farmers to be able to diagnose their diseased animals. DigiVet is still being developed and improved, in 2017[16].

5.5 CASE: NEEDS ASSESSMENT WITH FARMERS IN MALI

In 2014 the W4RA team started a collaboration[17] with Malian farmer organization AOPP[18], aimed at improving access to information and communication for smallholder farmers and pastoralists in Mali. AOPP is in fact an association of about 240 smaller farmer organizations with more than 40.000 members. AOPP's objective is to improve living conditions of farmers and achieve food self-sufficiency through peasant agriculture, family farming, multi-functional scaling methods, within the strategic framework of poverty reduction. AOPP has a presence in the whole of Mali. The members of AOPP are small scale farmers and pastoralists.

AOPP invited our team to discuss how to improve communication and access to information for smallholder farmers in Mali. At AOPP's request, our team organized a series of needs assessment workshops in Bamako, with participation of a group of twenty farmers, all coordinators for AOPP in different regions in Mali. The methods, techniques and tools, used for the needs assessment are described in the following sections.

In October 2015 the first needs assessment workshop took place at the office of AOPP in Bamako. Eighteen farmers from different regions participated in the workshop: Mopti, Tombouctou, Ségou, Sikasso, Bamako, Gao. The ICT developers team consisted of six people. Two potential, local service providers joined our team: an expert in rural development and community radios, and one ICT expert from a small Malian ICT-enterprise.

16 A poster, by Gossa Lô about this system can be seen at https://w4ra.org/wp-content/uploads/2015/05/Poster_Gossa.jpg (accessed 31-07-2019)

17 The workshops with AOPP were facilitated by a grant from Nuffic within the NFP-TMT program.

18 AOPP is an acronym for Association des Organisations Professionnelles Paysannes.

During the first of the four-day workshop presentations, demos, plenary discussions, interviews and work in smaller subgroups are done. The session is opened in Bambara language by the executive secretary of AOPP. This is followed by an introduction round. AOPP is introduced by its executive secretary. He summarizes the major constraints of smallholder farmers and pastoralists in rural Mali. Talks and discussions are in French. Simultaneous translations are made in Bambara and Dogon on the fly, for the participants who are not fluent in French. The president of AOPP does not speak French, only Bambara.

The first day is spent on introductions and demonstrations of (voice-based) mobile systems in African languages. Demonstrations are given of various examples of information systems. A demonstration is given of a local digital weather station, which can collect and diffuse information on local rainfall, and other meteorological data, see Figure 21. As the water supply was temporarily unavailable at AOPP's office (a recurrent problem in Bamako) Tangara, inventively, pours old coffee in the rain gauge, to demonstrate to the group how this digital meteo data service works.

The farmers show interest in receiving information on actual amount of rainfall per day, during the rainy season. This information, if available as a voice message in local language, on a daily basis, is considered useful for taking seeding and harvesting calendar decisions.

After demonstrations three subgroups of 5-6 participants each, are requested to make an inventory of domains of concerns and related problems, in terms information needs. During the group presentations, the moderator tries to elicit the problems and describe them in terms of goals, stakeholders, relationships and opportunities.

After the working sessions of 1,5 hour, group results are presented in a plenary session. Key ideas, user stories and business ideas are discussed, grouped and summarized. This resulted in five domains: (i) agriculture, (ii) animal rearing, (iii) fishery, (iv) agro-forestry, (v) internal organization of AOPP. The groups make a longlist of general constraints, which are presented next. Some participants are unable to write. Each group appoints a scribe.

The following list in Figures 22 and 23 were produced based on the discussions about domains and related information needs. At first, the participants write down large challenges. As these are too complex, they are decomposed into different smaller problems which might be easier to tackle. The results are summmarized in Table 1.

In a further session they go into detail on concrete problems, related to information and communication. The moderator asks to be specific and add operational goals to each challenge. This is an iterative assignment which yields information on an increasingly higher level of detail and specificity. This is necessary to model and design information systems.

GROUP WORK RESULTS The constraints to information and communication which came out of the workshop are (i) lack of infrastructure in rural regions (no electricity,

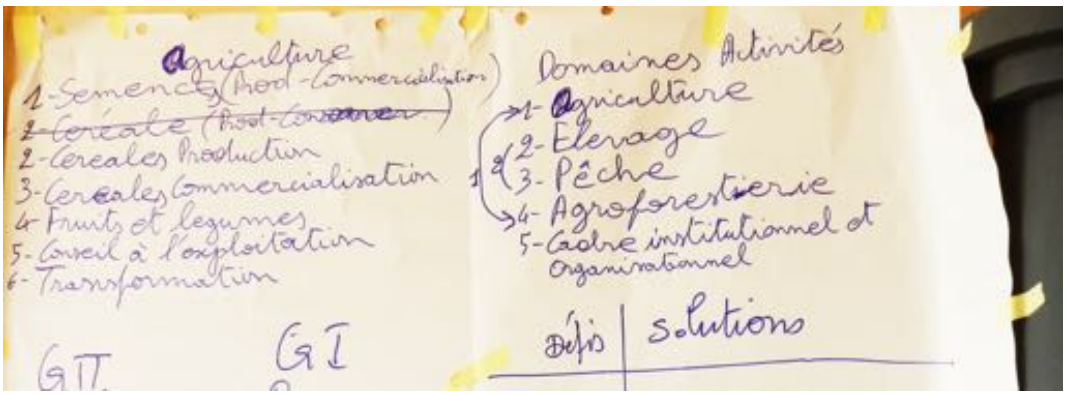

Figure 22: Result of needs assessment workshop with farmers in Mali. First step: inventarisation of the different domains, 10 October 2015.

Figure 23: Second step: brainstorming about problem and solution spaces, related to information and communication needs.

DOMAINS	INFORMATION NEEDS
agriculture	seeds, fertilizers, transporting services, trade
regreening	agroforestry, production, trade, transformation techniques
livestock	animal health, vaccination schemes, conservation of milk, trade
fishery	fish conservation, transport, trade
market information	broadcast offerings, access to customers, local markets
soil & water	water conservation, information on techniques, irrigation methods
meteo	weather forecasts, indigenous knowledge, cropping calendars
alert systems	alerts on floods, outbreaks of disease
legislation	information about tree laws, in local language, easy access
farmer organization	communication; monitoring system; diffusion of information

Table 1: Domains and topics and related information needs

no internet); (ii) common illiteracy; (iii) variety of languages; (iv) low income. (This is consistent with earlier workshops which we did in Mali and Burkina Faso.)

The existence of full coverage of community radio and the wide availability of (GSM, voice-based) mobile telephony in rural regions, are opportunities. Advanced ICTs (such as smartphones, computers, internet-dongles with mobile internet connections are only owned by local NGOs, rural radio stations and agro-extension workers, and some youngsters in the villages, who often travel to urban areas. When available, mobile internet is very expensive: prices are comparable to voice-based access, 100 fCFA per minute.

The following types of information needs are formulated: (i) information/knowledge retrieving, e.g. getting information on market prices, weather forecasts, animal diseases, seeds etc. (ii) communication/knowledge sharing, e.g. inform others about local rainfall, fire alerts, regreening techniques etc. (iii) information/knowledge dissemination and broadcasting, e.g. sending announcements to inform a large public e.g. advertisements, invitations for an event, weather alerts etc.

5.5.1 *Finding key ideas: seeds*

One of the interesting key ideas was to have a seeds information system. The AOPP staff suggested us, during the workshop, to co-create a seed information system for farmers in remote areas. The system must be accessible through mobile phone, in local languages. For the developers' team to obtain as much information about seeds, an interview with a seed expert was done, and a field visit took place, the next day. With this information, the W4RA team built a prototype, during the workshop.

Figure 24: Field visit and context analysis with workshop participants: AOPP farmers and W4RA team (south of Bamako, 12 October 2015, Photo: Victor de Boer.)

USER STORY: SEEDS Henri, farmer and coordinator of farmer organizations in the Ségou region for AOPP, gave me this information in a short interview[19].

Seeds in Mali are produced and provided to farmers by a national research institute[20]. These seeds are referred to as *semences de base*. Seed producing farmers can obtain these basic seeds for the large scale production of second generation seeds, referred to as certified *"R1"* seeds, which are allowed to be sold on the market. The problem is that the sales of seeds is hampered by lack of communication, as farmers in rural villages are often illiterate and do not have computers or Internet. Therefore a system or service should be useful, where farmers can offer seeds for sale or request seeds for purchase.

In southern Mali, various cereals are produced. Farmers must decide what they are going to produce next year, and which seeds to buy. AOPP collects information from all its members, from the whole country, and asks what they are producing, and which seeds they are requesting. Given the poor communication channels, this information is available centrally, i.e. at the AOPP headquarters in Bamako, but does not go back to the farmers at the start of the chain, i.e. in the unconnected rural areas.

FIELD VISIT WITH AOPP To better understand the context of seeds in Mali, in October 2015, we visited, with the group of twenty farmers from AOPP, a field where AOPP does field experiments with seed varieties and new cropping techniques. Figure 24 gives an impression of this field excursion.

19 During the workshop at AOPP, 11 October 2015

20 Division de la Recherche Agronomique de l'IER, la Section de Contrôle et de Diffusion des Semences Sélectionnées (SCDSS).

RAPID PROTOTYPING AND EVALUATING IDEA FOR SEED SYSTEM Based on this request, a first (rapid) voice-based prototype was built, and demonstrated during the workshop. For the sake of simplicity, the prototype was in French – not local language. It has a mobile voice-interface. Without bothering much about the exact content (seeds, names, exact workflow), this prototype, built overnight by our developers' team[21] gives the farmers an idea how a voice-based mobile applications might look and feel.

For the developers it is good to know if the users know how to press the phone buttons (DTMF – dual tone multi frequency is pressing a key in answer to a voice dialogue). Is the voice menu structure clear enough? Below is an example of a demo dialogue (the original version was in French), built and shown during the workshop, for a possible seeds information system. Below is the phone of a prototype for an mobile/online seed market. Farmers can call to this system to place offerings of seeds and browse current offers of seeds of various quality levels, in a specific region.

```
* Welcome to the AOPP seed market place.
* If you have seeds to offer, press 1.
* If you are looking to buy seeds, press 2.
* If you want information about seeds, press 3.

* What type of seeds are you looking for?
* What type of seeds do you have to offer?

* For red rice seeds, press 1.
* For fonio seeds, press 2.
* For nere seeds, press 3.

    * Select the quality of your seeds.
* For semance de base, press 1
* For R1, press 2
* For R2, press 3

* Press 9 to go back to the start menu

* What is your Cercle
* For Mopti, press 1
* For Tominian, press 2
* ...

* You are offering:
* red rice seeds in the Tominian cercle
* fonio seeds from the Tominian region
* nere seeds in the Bamako region

* Please enter your name and phone number so potential clients can contact you
```

21 Victor de Boer and Wendelien Tuyp made this prototype in one evening.

```
* We found two offerings in your region:
* Zakari Coulibaly is offering fonio seeds in Bamako, 6*****22
* Pierre Keita is offering fonio seeds in Tominian, Rue du Blabla, 9*******5
```

This prototype gives an idea (look and feel) to the envisaged users, how a possible seed information system might work. A mobile, voice-based seed information system is one of the key ideas and wishes of AOPP for its members (farmers in Mali). This will be further elaborated into a system, in the near future, e.g. in 2018.

5.5.2 *A milk information system*

Another key-idea that emerged from the discussions with the pastoralist members from AOPP was related to the value chain for milk in Mali. With more than 10 million cattle and 32.7 million sheep and goats, livestock rearing in rural Mali is an important source of food and livelihoods for nomadic and sedentary pastoralists and farmers [59]. It contributes to rural household production systems[22]. Where milk was formerly sold by the producers standing with their products along the road, value chains for dairy are gradually improving due to improved local organizations. Rural pastoralist organizations and cooperatives strive to enhance the economic position of milk producers[23].

FIELD VISIT TO A SMALL DAIRY COOPERATIVE In May 2016, the research team organizes a field excursion to a small dairy cooperative named "Cooperative de producteurs de lait Ouelessebougou", a member of the union of milk producing cooperations in Mali, see Figures 25 and 26. This (iterative) context analysis and needs assessment was necessary to learn and help improve information exchange between milk producers and the cooperative.

Our partners from farmer organization AOPP introduce us to the coordinator of Ouelessebougou and a few other members, and help us by translating during the meeting between Bambara and French. The technical installations of the factory are visited first. After the tour we have a focus group discussion, to understand the context, the operational goals and the information needs of the milk producers. The focus group is done with a group of about 25 people, including the coordinator of the cooperative. It gives us a general idea of the context and a first idea about information needs.

FOCUS GROUP WITH DAIRY COOPERATIVE This cooperative receives milk from 3 communes and 600 milk producers, who provide a total of 1500 liters per day. A Malian cow produces no more than 2 - 7 liters a day. Commonly this milk is extracted by hand. A member of the cooperative fetches the milk in the villages and brings it to the dairy

22 Source: http://tinyurl.com/shareweb-pastoralism-mali (accessed 31-07-2019)

23 See e.g. https://www.theguardian.com/journalismcompetition/mali-milk-production (accessed 31-07-2019)

Figure 25: A field visit to dairy cooperative Ouelessebougou. Focus group discussion after the visit to the small factory, 8 May 2016. Photo: Leeuw van Moerkerken.

factory by motorcycle. Milk has to arrive here within 4 hours after extraction. The milk temperature has to be between 21 and 35 degrees Celsius during transport, and it has to be tested within that temperature range. Conservation of milk is a problem in Mali, with daily temperatures of up to 40 degrees Celsius. Milk can be kept fresh for four days after pasteurization (when refrigerated). Part of the milk is transformed into yoghurt, in this factory. The milk is tested, pasteurized and packed. It receives an official quality certification. The milk is sold here at 300 fCFA per liter. At the market in Bamako it costs 450 fCFA per liter.

The members of the cooperative tell us their concerns. The match between milk producers and buyers is difficult. Milk is a highly perishable product. Its production amount varies considerable between the rainy and the dry season, when there is not much to graze for the herds. In Bamako, milk is mixed with milk powder, and sold at a lower price. Our dairy cannot compete with these low prices. Communication with the producers is a problem. Radio and mobile phone are already used, but communication could be largely improved.

Another problem is the poor sales network and inadequate refrigeration facilities. This means that resellers can only obtain a limited quantity of milk. In Mali there is hardly a demand for yoghurt or cheese. There is still a long way to go, to improve the milk value chain. This cooperative holds a good administration, however, all administrative data are stored and processed on paper, on the wall see Figure 26.

A PROTOTYPE MILK INFORMATION SYSTEM Based on the discussions with AOPP farmers and their wish to improve information exchange for the milk sector, a preliminary idea is developed to improve the communication between the producer and the

Figure 26: At the office of milk cooperative Ouelessebougou. All data about the milk is kept on paper. The fresh milk and yoghurt are sold in small plastic bags, 8 May 2016. Photos: Anna Bon and Leeuw van Moerkerken.

collector of milk. A simple prototype is built for a voice-based milk information system by developers/researchers[24] from the W4RA team[260]. This prototype is presented to the farmers of AOPP in June 2016. It is currently still under construction[25] in December 2017.

5.6 CASE: METEO SERVICES FOR FARMERS IN BURKINA FASO

During various collaborative workshops[26] with farmers in Burkina Faso, Mali and Ghana between 2010 and 2017, one of the information needs most often mentioned was information about weather, specifically rain forecasts. Farmers were interested in receiving timely and accurate information on the (cumulative) amount of rainfall in their own region. During the rainy season this information is required every day.

Agriculture in West Africa is mainly rain-fed. In the Sahelian zone of Burkina Faso and Mali the rainy season extends from June to October. Cropping and harvesting are done during the rainy season. Meteorological information is of great importance for farmers. Daily information on fallen rain, is important to plan cropping calendars. Our project partner in Burkina Faso, the NGO Réseau MARP explains that in recent years (1991-2009) rains have become more erratic and less predictable, probably due to climate change. Heavy rains and floods in various regions have caused casualties and soil erosion.

24 Aske Robenhagen and Bart Aubers developed the "Mali Milk" application as part of the ICT4D course 2016 at VU.

25 A full report by Aske Robenhagen can be downloaded at https://w4ra.org/wp-content/uploads/2016/07/Downscale2016_paper_2.pdf (accessed 31-07-2019)

26 These workshops were partially financed by a grant from Nuffic in the NFP-TMT program.

Figure 27: Farmers in Burkina Faso, Gourcy discussing the manual raingauge in the field. All data on rainfall, collected by farmer Oumar, is stored on paper, 23 June 2016.

5.6.1 *Example of a series of collaborative workshops with farmers in Burkina Faso*

In January, April and July 2014 the W4RA team[27] holds various focus group discussions with farmers-innovators from the Zondoma and Yatenga regions in Burkina Faso. We visit local radio stations: La voix du paysan, Radio Solidarité, Radio Notre Dame du Sahel in Ouahigouya, and Radio Savanne in Gourcy. The radios are already broadcasting information on rainfall for the local communities, on a daily basis during the rainy season. We visit the fields of several farmers – innovators. Many farmers are already collecting rainfall data on their fields, using rain gauges which they received from NGO Réseau MARP, including a short training how to use them. Rain information is still difficult to share with other farmers, due to absence of good communication channels.

The first goal is to find out the need and co-design possible solutions, related to weather information. Information on the Web is not accessible for the farmers in this region, who only speak Mooré, and do not have an Internet connection. Understanding what the farmers really want requires dialogues, group discussions and demos of possible solutions through prototypes. The feedback of the farmers will be used for further improvement of the systems. This takes several cycles and frequent face-to-face meetings.

27 The W4RA ICT developers team consists of 4 to 5 people, including myself.

Figure 28: Workshop and field visit W4RA team and innovative farmers from the Yatenga and Zondoma regions, Burkina Faso, 23 June 2016.

After an interruption of this project in 2015 (due to temporary lack of project funds), in 2016 the needs assessment is taken up again. Another field visit is done to the same locations in Gourcy, Zondoma region, in Burkina Faso, from 21 to 24 June 2016[28].

This is a follow up of meetings in January, May and July 2014, with the same group of farmers-innovators and radio stations. This time, not only farmers, but also staff from the national meteorological service and staff members from a number of local radio stations participate in the needs assessment workshop. In total 24 people including the moderators. An excursion to the fields of one of the participating farmers, is part of the workshop. We visit the field and see how farmers are currently collecting rain data, see Figure 27. We sit together with the farmers, to discuss the issues surrounding meteo data, see Figure 28.

THE METEO WORKSHOP - DAY 1 The first workshop day is spent reviewing the meteo data collection projects, which are already going on in the region: one project with the Direction Generale Météorologique. The second day is for further elicitation of the farmers' information needs and to brainstorm about possible solutions and applications.

We are told that the national meteo service sends a bulletin by email to a number of recipients, with the actual weather forecasts. To inform the public, the regional radio stations from Ouahigouya, La Voix du Paysan broadcast a program with the current

28 This is done by Wendelien Tuyp, Hans Akkermans, Francis Dittoh and myself, in collaboration with the director and three staff members of Réseau MARP.

meteo forecasts from the bulletin. This is broadcast twice a week, during the rainy season.

We discuss another meteo project, which is coordinated by Réseau MARP. This meteo project is about collecting local rain data and aggregating this to disseminate it to the communities (See Figure 29). This project fills the gap of local information needs, which the national meteo services are not able to bridge.

This development project, managed by Réseau MARP, is done with a number of farmers, who receive a short training how to collect rainfall data in the field using a rain gauge. These data are written down on paper by the farmers (who have been selected for this pilot based on literacy). Farmers give this information by phone to a person, who aggregates all the rain data from the region concerned, and sends them to Réseau Marp. A staff member from Réseau MARP currently enters all data into an Excel sheet. This sheet is forwarded to the local radio for broadcasting. The project is effective and appreciated by the farmers, however, it is time consuming for the NGO and for the radio stations[29]. Another problem is that the info is only broadcast at certain hours, so many farmers do not get the information, when they are working on the field.

After the plenary session, the group is divided in smaller groups of about five or six people each. The difficulties that are encountered related to meteorological data, are discussed and written down on a large piece of paper. This is presented by one member of each team in the plenary session. (Many of the participants in this workshop only speak Mooré. Group work allows them to discuss and brainstorm in their own language, and report the outcomes back in the plenary session.)

The difficulties encountered by Group 1 are (i) there are not enough rain gauges in the field to have sufficient rain info (ii) the phone network is often unavailable in the villages (iii) the internet connections are poor for those who have to use this e.g. the radio stations (iv) people do not have radio receivers at home (so many families cannot listen to radio) (v) currently, information is broadcast based on administrative regions. The farmers are used to other names, which they refer to as the "real" geographic names (vi) radios complain about the costs of making phone calls to send the information to the information gathering people.

There are solutions proposed in the various groups: (i) give farmers rain gauges and radios (ii) improve network connections; choose a better network operator (iii) make farmers aware of the administrative names of the regions (iv) revise tariff–cost structures for all kind of data services including phone and radio broadcasts.

WORKSHOP METEO DAY - 2 The second day is spent on further analysis of information needs and possible solutions. The group of innovative farmers express a wish to have weekly and daily weather forecasts in the rainy season, for example when it

29 The needs assessment yields the need to improve the existing workflow. This is what we refer to as a legacy system.

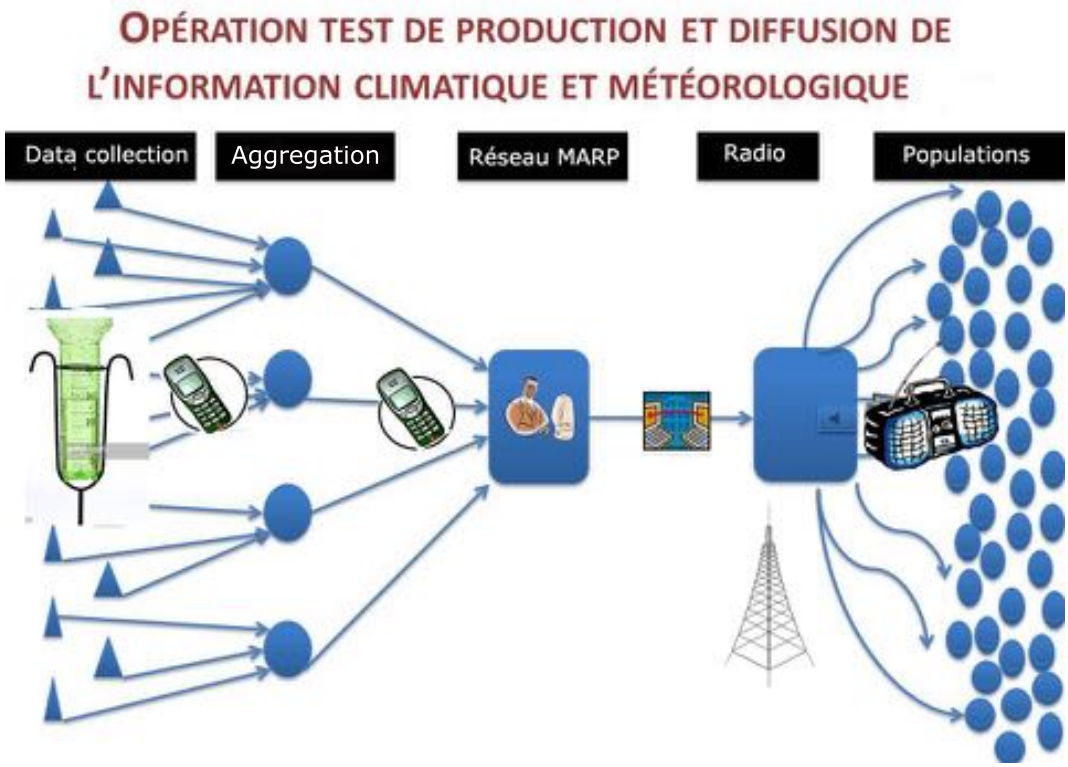

Figure 29: Conceptual model showing the collection of rain data, and its aggregation and broadcasting on the local radio stations. This model represents a key-idea for a voice-based mobile data service. It is based on an existing (legacy) system, which is running since 2014. Courtesy of Julien Ouedraogo, Réseau MARP

will start and end; want heavy-rain alerts, and want to have accumulated rain data per week (in mm, cm). They prefer to have this on mobile than on radio (as they do not carry the radio into their fields).

They would like to receive the information on a daily and weekly basis. Why is this of interest to the farmers: forecast for season helps them to know which seeds to use on what locations and in what period; daily info allows to plan the daily operations. Problems encountered: (i) the radio as well as meteorological services have a poor internet connection; (ii) not enough training in meteo domain for radio people; (iii) meteo organization is understaffed; (iv) not all farmers have radios at home.

5.6.2 *Summaries of group findings*

The work in groups provides concize information about the needs and concerns of the farmers. Each group has appointed a scribe (since not all people have literacy skills, or speak French). Groups are mixed: farmers, radio journalists and meteo people. A summary of two of the group results is given below.

SUMMARY OF GROUP II – DAY 1 Project going on, managed by Réseau MARP (RM): actual rain data collected in villages (pluviometry via rain gauges), then aggregated centrally at commune level, then aggregated centrally to RM, then from there sent to Radio Savane that distributes this weekly on Friday 08.00h;
There is said to be feedback from the population to Radio Savanne;
The same info is sent also every 10 days to the province level and the rain info from Gourcy and Tayo is also sent to the national meteo service Direction Génerale Météorologique (DGM);
Several meteo stations also send their info to the DGM;
DGM sends around an email bulletin to a mailing list (unspecified, but includes Radio Voix du Paysan) and do short radio and tv broadcasts;
Difficulties: (1) telephone network weak; (2) poor coordination of all the info streams; (3) sustainability of the system is questionable ;
Possible solutions: not yet discussed.

SUMMARY OF GROUP II – DAY 2 Want to have: (1) rain forecast; (2) forecast of wind; (3) forecast of the sun intensity; (4) number of rains that have fallen;
Channel preferred: (1) mobile (2) radio;
See also flipover on Figure 30. Frequency: (1) weekly; (2) every 3 days; (3) every day (4) every month;
Why? (1) for cropping calendar; (2) for the choice of which variety of seeds (e.g. early or late ones); (3) to know about wind helps to avoid crop diseases; (4) sun intensity is

a factor in crop growth; (5) accumulated rain data help forecast on productivity.

SUMMARY OF GROUP III – DAY 1 Actual rain data is collected in villages, then aggregated centrally at commune level, then sent by mobile phone to resource persons, then it goes to the radio by mobile (and apparently broadcast);
Diffusion of information gives an idea locally of the evolution of the rainy season; it allows farmers to take decisions e.g. on seeding; gives also flooding alerts;
Farmers are already collecting rain data for 20 years; 33 rains is a good year; 4 rains or more in June is a trigger to start seeding and will give a good harvest;
Difficulties: (1) poor mobile network; (2) farmers do not have rain gauges and do not know how to use them; (3) there is not a formal organized system in place to diffuse the info.

SUMMARY OF GROUP III – DAY 2 Want to have: (1) rain forecasts every 3 days; (2) rain fallen (in mm); (3) alerts for strong winds;
Channel preferred: (1) mobile (2) radio [Note: costs are a concern];
Frequency: every 3 days;
Why? (1) helps plan cropping calendar; (2) prepare yourself for strong winds;
Missing: (1) info not available in the right language.

5.6.3 *Collaborative decision making*

The last day of the workshop, after the field visit, the following to-do list is made by the group of participants. The following data (provided by different parties) will be needed to build and deploy the system. The list is set up by all participants (workshop facilitators (ICT developers) and envisaged users).

- Global and local data integration service meteo Burkinabe DGM, INERA, Réseau Marp, *et données au niveau des communes* etc;
- Collaboration with VU-Réseau MARP for the recording of speech/dialogues in Mooré for the application;
- Developers at VU/2Coolmonkeys design/build a new prototype based on the requirements of this workshop;
- Key users: farmers, radios, for the evaluation of the systems during their development;

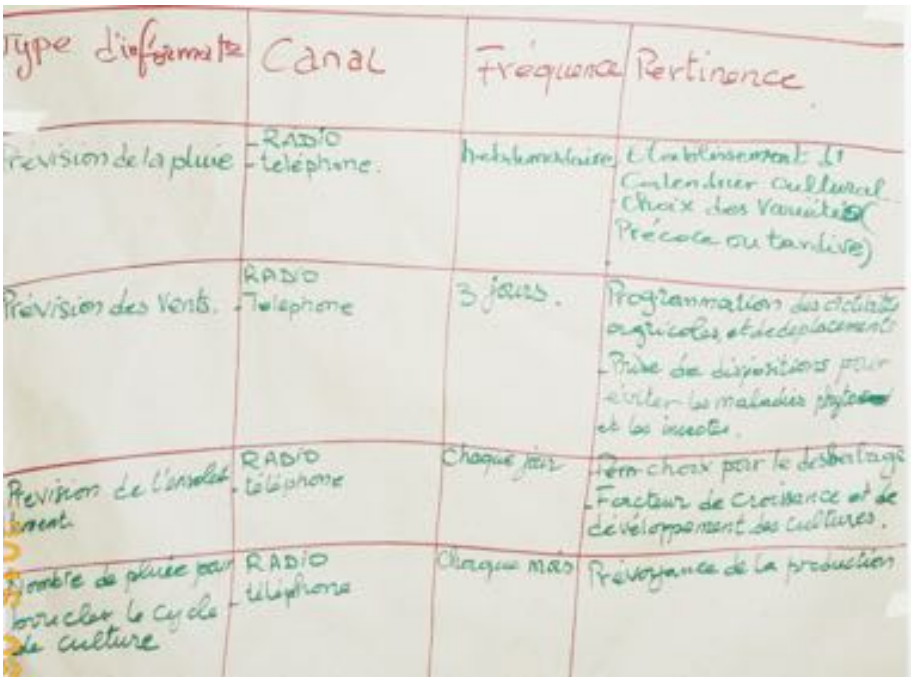

Figure 30: Results of brainstorm during the workshop in Gourcy, Burkina Faso, by farmers, meteo experts and local radio journalists: discussing the solution space.

- Business/technical partners: local technical/ICT/radio people, entrepreneurs (radios, NGOs, entreprise TICs);
- Lobbying at national level to raise awareness of the need for accurate/localized/-timely local rain data. This can be done by Réseau MARP.

5.6.4 *Jointly defining the solution space*

After various needs assessment workshops with farmers in Burkina Faso, it is clear how important meteo (and specifically rainfall) data are for farming in rural Africa. A number of key ideas is collected, i.e. a solution space is defined.

Farmers expressed the need to have better access to weather data, and to be able to upload their own collected data, to share that with other farmers in the region. This can be summarized as three types of key ideas concerning meteo and weather.

The different key ideas for meteo are shown on Figure 31 as a concept map. The importance of having a technical Meteo Data Service Platform, to host the different data services (in the absence of a good Internet infrastructure in the region) is also an outcome of the needs assessment workshops. The constraints due to lack of computers/illiteracy also lead to a number of choices. This concept map can be considered a portfolio of key ideas related to meteo data services in rural Africa.

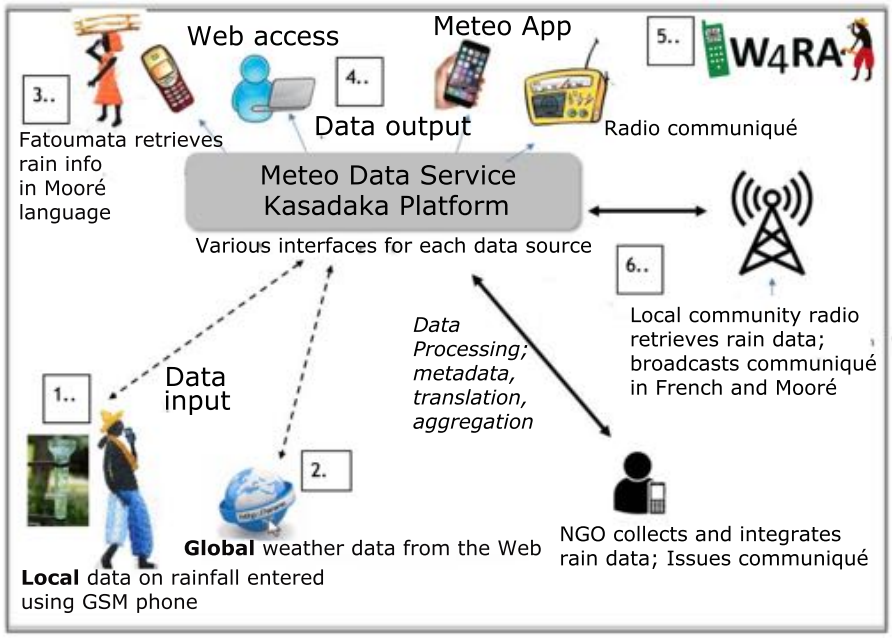

Figure 31: Conceptual model of a mobile/voice-based technical platform. This model also shows the portfolio of key ideas for meteo data services for farmers in this region of Burkina Faso. Source: Anna Bon. (A description of the Kasadaka Platform is given in Chapter 7)

.

1. Daily weather forecast (amount of rain) for the next 1-2-3-4-5 days;
2. Alert in case of heavy winds/storm;
3. Amount of rain (in mm) fallen overnight, locally or in the region.

The daily weather forecasts and storm alerts are currently already available on global online weather services on the Web. However, due to a lack of computers or smartphones and due to lack of literacy skills, farmers would like to have this info (points 1 and 2) accessible on their mobile phones in local languages.

The amount of rain collected in various regions, by farmers who measure rain data from the rain gauges in their fields, is not being diffused. Farmers would like to enter this data into a system and make this data available for the rural population. These ideas lead to various use cases which can be integrated into a suite of meteo applications for rural West Africa, see Figure 31.

Based on one of the key ideas, researchers and students[30] of the W4RA team built a prototype for a mobile voice-based information system in English and French[31]. A

30 Jari Ferguson and Kim Bosman developed this in June 2016 during the ICT4D course at VU.

31 A voice based weather informaton prototype in Mooré language is being developed for the farmers in West Africa by W4RA researchers André Baart and Francis Dittoh, and ICT4D master students in 2017.

prototype was tested in Gourcy by farmers, in June 2016. The farmers phoned a local phone number and interacted with the system, which gave them information on the latest weather forecast [31].

This development of meteo data services for farmers in Africa is an ongoing project which will be continued in 2018, as part of the ongoing W4RA research program.

5.7 SUMMARY

As illustrated in this chapter, the proposed method for needs assessment is collaborative, and rooted in the local context. Methodologically, there are similarities with workshop methods used in agile methods and living labs. The main difference is the method for *collaborative goal construction* and joint decision making with end-users about the problem and solution spaces. This is based on assessment of what users and their communities have as operational goals. This links to their livelihoods and local value activities.

Having collected a long list of user needs, the next step in the process will be to describe/design use cases and elicite user requirements for an envisaged solution. The process of use case and requirements analysis and conceptual modeling of the system is also done in collaboration with the users. This process is described in Chapter 6.

6 USE CASE AND REQUIREMENT ANALYSIS

In the process of collaborative ICT4D development, a list of project key ideas is collected during needs assessment workshops and context analysis (described in the previous chapters). From this list of key ideas a selection is made of the best and most promising project ideas. These will be further elaborated into an ICT4D system or service, through an iterative process in which we are "spiraling down" from a vague and often poorly specified idea through various iterations, towards a concrete design in which all requirements are defined, tested and formally specified. This process requires intense two-way knowledge exchange in order to transform the key idea into a technically specified model with the right requirements. To do this we propose a "structured narrative method", which optimizes the (collaborative) process of use case and requirements elaboration[1]. This is a way to bring the second Principle for Digital Development into practice: Design with the User[2].

6.1 USE CASES AND REQUIREMENTS IN ICT4D

This chapter presents a method for use case and requirements analysis and elaboration, which can be used in software development projects in which: (i) the cultural background of users and developers is very different, so that communication deserves special attention; (ii) the context is complex and may be unfamiliar to the developers. As these conditions are often encountered in ICT4D projects, this method is specifically useful for software development in low resource environments.

To build ICT solutions it is necessary to find user requirements – i.e. what the users want the envisaged system to do. A requirement, in software development, is defined as a property, a functional behavior of a software system [33].

This process may be difficult when e.g. users are unfamiliar with ICT, when developers are unfamiliar with the local context, or when there are large differences between developers and users in e.g. language, educational or cultural background. (This in contrast to ICT/software development projects in the Global North, where developers and users are more likely to share the same language and culture.)

1 Parts of this chapter have been published previously as a project deliverable in the EU-FP7 VOICES research project: Anna Bon & Hans Akkermans (Eds.) Deliverable No D1.1. VOICES Use Cases and Requirements (2011) https://w4ra.org/wp-content/uploads/2014/08/VOICES_D1.1-v1.0-VUA_FT-28Sep2011-final.pdf, (accessed 31-07-2019)

2 https://digitalprinciples.org/ (accessed 31-07-2019)

To facilitate use case and requirements elaboration we developed a "structured narrative method". This method structures the information collected during workshops and face-to-face meetings.

The method facilitates communication about requirements (i) with end-users in a non-formal way, using narratives and pictures, sketches, cartoons or storyboards; (ii) between technical developers in a formal way, structuring the information and capturing the technical system specifications. The method will be explained in the following sections.

6.2 FROM UNSTRUCTURED IDEAS TO USE CASES AND REQUIREMENTS

Having selected during the needs assessment workshops a list of key ideas, the next step is to analyse and elaborate use cases and requirements. This is an iterative process that requires (again) good communication between developers and users.

During co-creation workshops software developers discuss requirements with key users, however, users – especially when they are not technical – find it difficult to formulate requirements. It is therefore the requirements engineer's task to facilitate requirements. This is done using various techniques.

The next step is to analyse, decompose and structure all information. We therefore use a "structured narrative method" that is understandable for end-users while providing a specification baseline for technical development, which can be gradually extended, by technical developers.

6.2.1 *Co-creation workshops*

While the use case and requirement workshops can be similar to the needs assessment workshops (all workshops are co-creative), the focus during use case and requirements analysis is more specific, and enters into deeper and more specific technical details. The aim is to bridge the gap between the (unstructured and rather vague) user story and a fully specified formal model for the envisaged ICT system.

To elicit requirements prototypes are (re-) built, and iteratively improved. Scenarios and storyboards are designed and discussed with the users. Business requirements are discussed, to assess the system's sustainability *ex ante*.

6.2.2 *Techniques used during use case and requirement workshops*

During the use case and requirements workshops developers give technology demos; short films are shown. In the presence of users prototypes are built. Users are given blanc (A1-size) paper and marker pens in different colors to sketch and draw models during small group assignments.

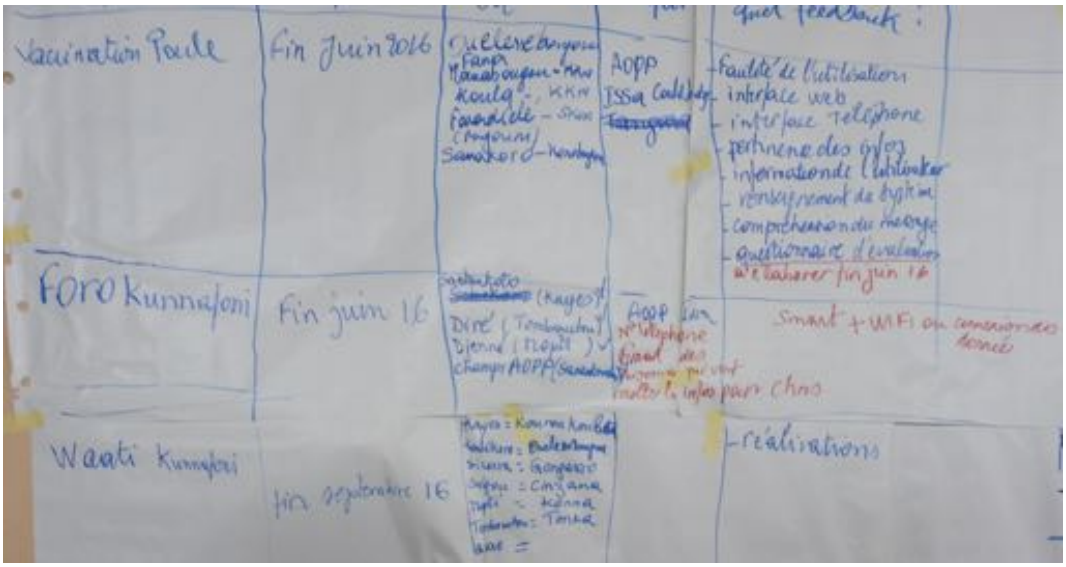

Figure 32: Example of outcomes of a selection workshop for key ideas/user stories collected with farmers of AOPP in Bamako Mali, May 2016. The selected key ideas are (i) mobile chicken vaccination alert service, (ii) a service to count cattle in the field, (iii) a weather information service, named Waati Kunnafoni.

To facilitate communication about the selected key ideas/use cases, a meaningful name is chosen for each key idea. These names must relate to the envisaged system and its goal/purpose. Names are preferably given by the users, in their local language. A meaningful logo is designed for each use case (by one of the creative workshop participants).

As an example, during various workshops with AOPP, (in October 2015 and May 2016) and farmers in Burkina Faso (April and June 2016, February 2017), we collected a number of key ideas. This included a mobile weather data service in local languages. This weather data service was coined in Bambara language *Waati Kunnafoni*. There was a mobile alert system for vaccination of chicken, a mobile system to count the number of cattle on a given terrain/area, named *Foro N'afa*; there was a milk information system and various other ideas, see the portfolio of key ideas on Figure 33. A logo was designed for each use case, see Figure 33.

During the co-creation workshops with farmers in Mali (members of the AOPP) and with a group of farmer-innovators from the Zondoma and Yatenga provinces in Burkina Faso, the following collaborative elicitation techniques were used.

RAPID PROTOTYPING: Development of ICT prototypes and demos during the workshop in the presence of the users, is a powerful technique for elicitation of requirements. This is part of agile development methods [85]. In contrast to deploying an end-application at once, this method ensures that solutions fit the local goals and con-

	System	Developers	Voice	Country	User group	Evaluator	Platform	DTMF	SIM	Current Language	Required	Quality (1-5)	Web interface	App interface	Call flow	Todo	v 0.2	Documentation
	forobaBlon on Kasadaka	André Francis	x	Mali, Burkina Faso	Radio @f	Tangara /Radio @f	Kasadaka	works	Orange Mali	Fr/ENG	Bambara/Malinké	3	4	n.a	4	Test by Radio @ Sikoboro	Language update	OK; update
	Foro N'Ata	Chris		Mali	Herder/farmer	Wren Horne	Smartpho ne	n.a.	n.a.	Fr	Bambara/ Soninke	n.a	n.a	4	n.a.	Test AOPP/Tangara	language	OK
	Forest Tracker	Chris		Mali	Farmer	Anna Wren Hunt	Smartpho ne	n.a.	n.a.	Fr/En	French/ Bambara	n.a.	n.a	4	n.a.	Test AOPP/Tangara	language	OK
	Weather forecast Kasadaka	Jari Kim	x	Burkina Faso + Mali	Farmers @f	Tangara	Kasadaka	works	Airtel/O range Mali	Fr/En	Moré/B ambara /Fr	2	n.a.	n.a		2,5 Weather data acc ess	Data+ website interface	OK; version 0.2
	Chicken Vaccination	Andre	x	Mali	Tangara	Tangara	Kasadaka	not yet possible	Orange Mali	Fr/En	Bambar a	2	2,5	n.a.		2,5 new requirements by Tangara; bargin	Elabora tion of outcall s	UML diagram
	Mali Milk	Aske Bart	x	Mali	AOPP		Web	n.a	Virtual box	En	Bambar a			n.a.		AOPP, Tangara	Port to Kasadak a; integrat ion	Update
	Waati Kumafoni	Chris		Mali + Burkina Faso	AOPP/R M	Julien	Web	n.a	n.a.	Fr	Bambar a	n.a.	4		n.a.	Testing by Banaou MAAP	local	OK
	Mr. Meteo	Chris		Burkina Faso	Julien	Julien Mathieu	Kasadaka	n.a	n.a.	Fr	Bambar a	n.a	5			Testing by Julien		

text. Users can give information, feedback, and evaluate the prototype immediately. Ideas and requirements are collected on notes, audio tape and video. The main advantage of rapid prototyping is that the communication between developers and users is optimal and can be discussed at once, without losing any time and having a risk of miscommunication about requirements.

STORYBOARDS: A use case storyboard is a central storyline – just like in a movie, video clip storyboard, animation, or demo, showing the event-state chain of the actors' activities and interactions. The main scenario is given in a well-structured narrative, e.g. through 1 to 5 steps. This scenario is developed in an early stage, shortly after the workshop as it is an important communication tool between developers and end-users. It summarizes the idea of the system, and makes it easier to discuss the various user and technical requirements. The use case scenario can easily be adjusted, expanded or refined based on feedback from the users. A storyboard is shown in Figure 34.

CONCEPTUAL MODELING: Often used in requirements engineering to visualize aspects of the real-world problem, convey the key points and facilitate communication about the design. Informal models can be used such as brief sketches, cartoons, scenarios, short films. Often, more technical descriptions are used, using UML (Unified Markup Language [270]). UML is a formal language with a graphical syntax. It can be used as a blueprint, providing detailed specification through different views on the system's architecture. In Figure 40 an example of a UML use case diagram is given. It shows the two different user categories in casu: (i) NGO-staff and (ii) farmers, and their (inter)-actions with the system. UML allows to model technical specifications needed for implementation of source code. In Figure 36 is an example: a UML state diagram specifying the different states of the system, the events and the variable names and types for each state of the system.

CONTEXTUALIZATION OF DEMOS AND MODELS: Since users in a low resource environment/ICT4D project may be unfamiliar with ICT, communication about the system design can be facilitated by contextualization of the demos and models. As an example: we made a visual call flow diagram for a voice-based information system in local language Bambara, to explain the basic idea of the system, and the different menu options. It helps elicitation and validation of the system's requirements. The translation of the text in Bambara language was done by our local partner Amadou Tangara, see Figure 15.

STRUCTURING ALL COLLECTED DATA: The co-creative workshops yield much information that needs further elaboration. We therefore propose a structured narrative method and a uniform format to capture all information, and make sure no relevant information is left unelicited. This method is described in the following section.

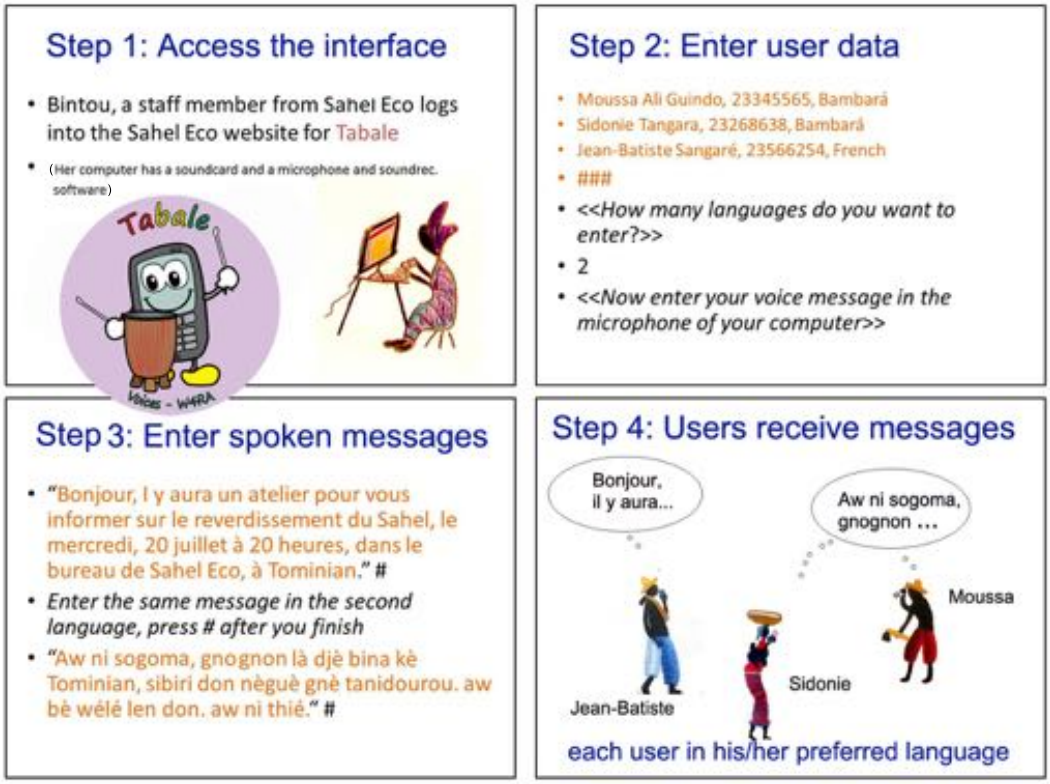

Figure 34: Storyboard showing a use case scenario for an envisaged mobile voice-based system in multiple languages. The use case was coined Tabale. Logo design by Victor de Boer, storyboard by author.

6.3 THE STRUCTURED NARRATIVE METHOD

Co-creation use case and requirements workshops generate a large amount of rich, but unstructured information (listings, tables, pictures, recordings of interviews, focus groups, prototypes etc.). In order to structure all this (rather patchy and messy) information and transform it into a set of formalized ICT specifications and models we need a rigorous, systematic method. We propose a method, which we will coin "structured narrative method", that facilitates (i) elaboration/formal technical specification of the use cases, (ii) communication about the requirements between developers and users and (iii) collaborative evaluation of design/requirements/technical specifications of the system's architecture. The method has been validated during our use case and requirements workshops from 2011 - 2017.

This "structured narrative method" has a format/set-up which is simple and compatible with guidelines, standards, and requirement for information system development and information architectures. The advantage of this approach is to get a uniform description of the various ICT ideas, in which all information is elicited. Data collected during workshops must be elaborated as soon as possible into this format, when memory is still fresh.

6.3.1 *The format explained*

The structured narrative method uses a structure format that provides a simple, but shared information basis and reference point for all participants (developers, users) in a uniform way. The set-up in 11 steps (0 to 10) is simple, but also compatible with software development guidelines, standards and methods which are used for information architectures [33]).

0. *Name – A characteristic, understandable, and distinctive label as unique identifier for each use case scenario.*
1. *Summary of key idea – What is the key (business) idea and why is it valuable or of interest to consider? (Short abstract, in a few sentences.)*
2. *Actors and goals – Who are the actors in the scenario and what are their roles/responsibilities and goals?*
3. *Context and scope.*
    a) What is the layout or network configuration of the interactions between the parties involved in the scenario?
    b) Who are the (external) stakeholders and what are their concerns?
    c) What is the scope of the scenario (especially: what is outside it, what is not considered, what is the system's boundary)?

   d) What are success or performance measures for the scenario (especially in relation to what a pilot demonstration should be able to show)?
   e) What are important (pre)conditions that must be or are assumed to be satisfied for the scenario (context features, e.g. needed resources or infrastructure or other characteristics of the environment)?

4. *Use case scenario script* – The central storyline (just like in a movie, a video clip storyboard, an animation, or demo; the script might e.g. be given in the form of a film or animation, showing the event-state chain of the actors' activities and interactions). The main scenario is given in a well-structured narrative, e.g. through 1 - 5 number of steps, of the following type: actor1, (inter)action, actor2.

5. *Interaction and communication* – Further script information, e.g. in the form of a few UML sequence, state or activity diagrams. (This gives some info about dynamics, interaction and control flows.)

6. *Information concepts* – Further script information, e.g. in the form of a few UML class diagrams showing the meaning of important concepts. (This gives some info on static data structures.)

7. *Technology infrastructure* – What are the consequences for technologies and technology components (Internet/Web, mobile, information, communication, voice services, both hardware and software) that must be (made) available in order for the scenario to work?

8. *Cost considerations* – What are estimated associated costs (operational, investment, development, in/outsource) for these technology infrastructure and components? Who carries these costs?

9. *Feasibility and sustainability* – The following checklist of questions needs answers:
   a) What is the technical feasibility of the scenario (e.g. risk analysis, technical obstacles to overcome, system-level impacts)?
   b) What is the business and (socio-)economic feasibility and sustainability of the scenario?
   c) What are possible goal conflicts and dependencies between the actors in the scenario?
   d) Are there preconditions for the scenario to work, and is it sufficiently interoperable with the wider context in a business/technical sense?

10. *Key requirements* – So-called MoSCoW list of requirements [317] (Must have, Should have, Could have, Won't have), as a starting point for further architecture design, and system and component development.

Figure 35: Informal sketch or model of the envisaged mobile event-organizer showing the scope of the system and its users. It shows the key idea of having a voice-based mobile system in multiple languages.

In the next paragraph the structured narrative method is elaborated for a key idea collected with users in rural Mali, cf. Figure 35. This was done in the framework of a European ICT research project named VOICES[3]First, the unstructured user story is given, as discussed during the workshop. Next, it is structured and modeled according to the proposed method.

6.3.2 *A key idea as unstructured narrative*

Sahel Eco is a small, local Malian NGO with headquarters in Bamako and branch offices in Tominian, Sevare and Mopti. In 2011[4], Sahel Eco had about 11 employees, of which two in Bamako and the others posted in the various regions, to have direct contact and be able to support the communities in the rural areas. Sahel Eco gives trainings and organizes farmer-to-farmer visits. Sahel Eco helps to disseminate and improve regreening initiatives, and trains farmers how to improve methods to make a living out of tree products. One of the activities is their support to emerging agro-forestry value chains, which will help farmers to sell their tree products.

Presence in the field is an important asset of Sahel Eco. Sahel Eco's employees are Malian experts in agro-forestry and local farming, most of whom raised in a rural community. Amadou Tangara was the chef d'antenne, posted in Tominian. While Tangara did not have a background in ICT, he soon became a key-user, co-creator and co-designer of various ICT solutions.

At Amadou Tangara's request the following key-idea was elaborated. Amadou Tangara organizes events and workshops on a regular basis, where rural communities

3 See the the VOICES research project, funded by the EU in the FP-7 program. See also https://w4ra.org/publications/voices/ ((accessed 31-07-2019).)

4 At the time of this research.

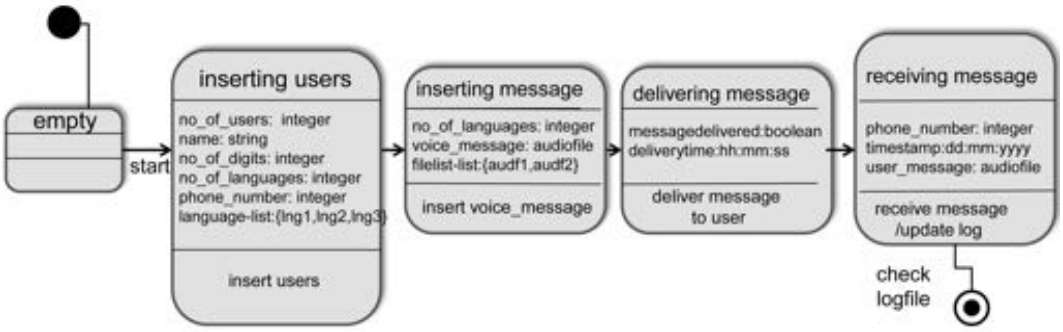

Figure 36: A formal model in UML: state diagram for the mobile event-organizer Tabale. This model shows the different states, state transitions, events and variables for each state of the system. These specifications are necessary for the technical development of the system. By Chris van Aart and the author.

meet each other (in e.g. the Ségou and Mopti districts in Mali), to change ideas and raise awareness about regreening. The invitees are farmers who live in remote villages, and only have mobile phone. They do not use SMS. Some are illiterate. Moreover, the farmers speak different languages: some speak French, others only local languages such as Bambara or Bomu. To organize an event, Tangara has to make 25 different phone calls, which takes him too much time.

The idea to facilitate Tangara's work, is to build a system that sends automated phone messages to a group. The envisaged situation is that a registered number of farmers receive an automated spoken voice message on the phone, informing time and place of an event or meeting. Farmers are addressed in their own language. They can phone back and retrieve the voice message again at a later time. The message is (optionally) issued in several languages.

Tangara must first enter a spoken message (in several languages), using a web-interface on his computer. Upon pressing the send-button, the system automatically calls a number of selected users on their mobile phones adressing them, each in his/her own language. An informal sketch of the use case is given in Figure 35.

6.3.3 *Structuring the key idea into the structured narrative format*

The user's narrative as illustrated above is elaborated using the structure narrative format.

0. *Summary of key idea* We want to build a system that sends automated phone messages to a group. The extension worker must enter a spoken message (in several languages), using a web-interface on his computer. Upon pressing the send-button, the system automatically calls a number of selected users on their

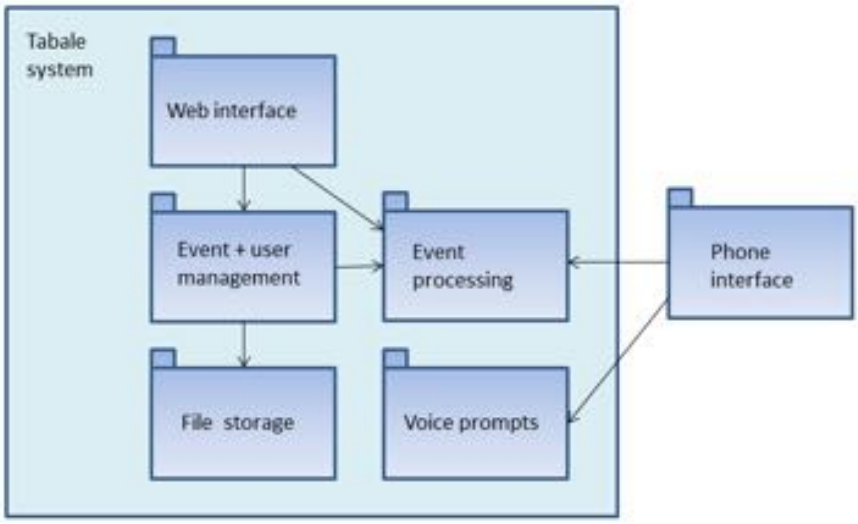

Figure 37: A view of the different modules and how they interact for the mobile event-organizer. Anna Bon and Chris van Aart.

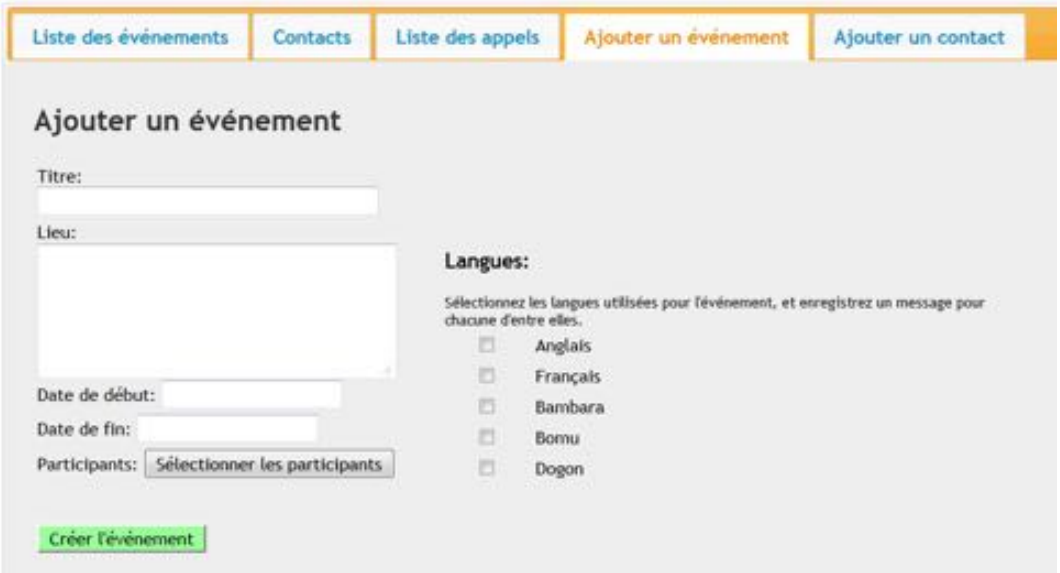

Figure 38: Screenshot of the prototype of Tabale, developed and built iteratively, Anna Bon, Victor de Boer, Nana Gyan, Chris van Aart, Max Froumentin.

Table 2: Stakeholders and their concerns for the Tabale use case.

ID	Actor	Description
1	NGO	Manage users and user profiles (add new/update/delete users)
2	NGO	Record audio in several languages (French, Bambara, Bomu)
3	NGO	Create an event (add date, users, message)
4	NGO	Manage events (add new; update; delete)
5	NGO	Monitor incoming calls
6	NGO	Launch event
7	Farmer	Receive phone message communicating event
8	Farmer	Respond pressing DTMF
9	Farmer	Generate communique report
10	Farmer	Call phone number to retrieve message
11	Support	Monitor system; maintenance

mobile phones, each in his/her own language. An informal use-case story board for this use case is presented in Figure 34. A screenshot of the system's web-interface in shown in Figure 38.

1. *Name and logo* The name given to this use case is *Tabale*. This is a meaningful Malian word, in Bambara language, referring to the traditional village king's drum. When there is an emergency or an important event or meeting, the messenger goes around by horse and beats the drum, to gather people to the village square. A logo for this use case was designed, see Figure 34 for the Tabale use case.

2. *Actors and goals* There are three actors, (i) a NGO webmaster; (ii) the farmer who will receive the message, gives a reaction (will attend meeting yes/no/does not know yet) and who can call back and retrieve the message at a later time; (iii) a person who provides technical support to the system. This information is summarized in Table 2.

3. *Context and scope for the Tabale use case:*

   a) *What is the layout or network configuration of the interactions between the parties involved in the scenario?* To describe the context and scope for the scenario, we sketch a layout or network configuration of the interactions between the parties involved in the scenario and we make a sketch of user/system interaction for the Tabale system, see Figure 35. The physical network requires a system or platform that can generate and send voice messages to the phone network. This platform is displayed in Figure 42.

   b) *Who are the (external) stakeholders and what are their concerns?* Apart from the users (the message sender and the receiving users) there must be service providers to deliver this service, including a local phone (GSM) network.

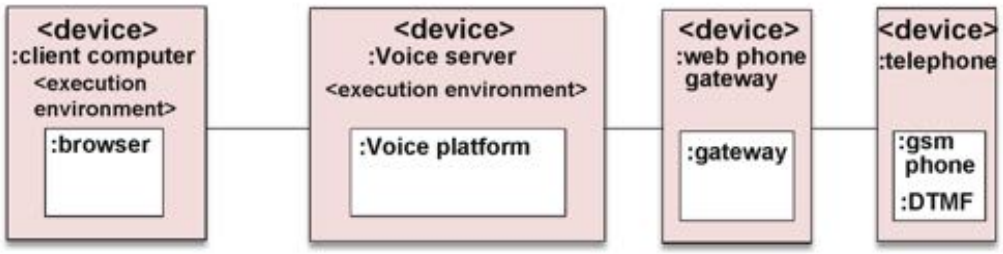

Figure 39: The requirements for the mobile event-organizer have consequences for the technical infrastructure. This is not trivial in the context of rural Mali. This model shows the deployment diagram for this system. Adapted after Chris van Aart

c) *What is the scope of the scenario (especially, what is outside it, not considered, system boundary)?* The scope for the case under consideration is shown in Figure 35.

d) *What are success or performance measures for the scenario (especially in relation to what a pilot demonstration should be able to show)?* The Tabale system is successful if the sender can issue a single message and multiple receivers can receive it by mobile phone, and are able to understand it, and reply to it.

e) *What are important (pre)conditions that must be or are assumed to be satisfied for the scenario (context features, e.g. needed resources or infrastructure or other characteristics of the environment)?* The system should work in the absence of an Internet connection in the villages where the recipients live.

4. *Use case scenario script – the central storyline (just like in a movie, video clip storyboard, animation, or demo; the script might for example be given in the form of a film or animation, showing the event-state chain of the actors' activities and interactions). The main scenario is given in a well-structured narrative.* For our case study this is shown in Figure 34.

5. *Interaction and communication – further script information, e.g. in the form of a few UML sequence or activity diagrams. (This gives some info about dynamics, interaction and control flows.)* This is shown in Figure 40 a UML use case diagram, a state diagram 36 and an activity diagram 41.

6. *Information concepts – Further script information e.g. in the form of a few UML class diagrams showing the meaning of important concepts that give some info on static data structures.* A class diagram is currently not available for this use case.

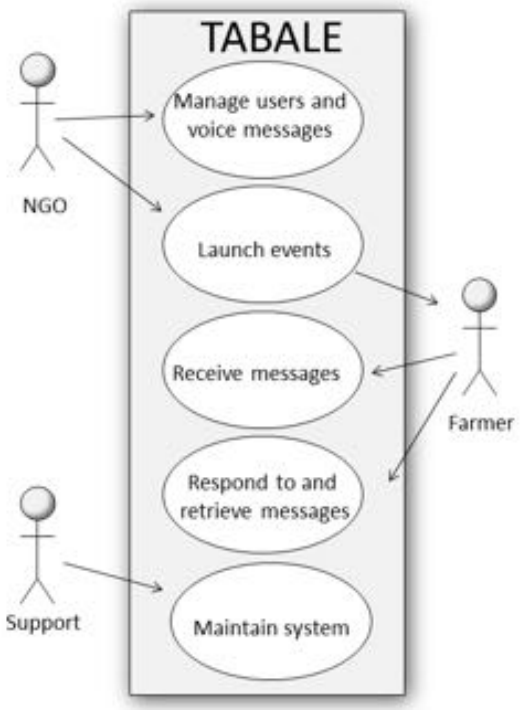

Figure 40: This user diagram for Tabale is for developers, but can also be explained to non-technical users, as it is a simple model. It shows the three categories of system users and the different task they perform in this system. By Chris van Aart and Anna Bon.

7. *Technology infrastructure: what are the consequences for technologies and technology components (Internet/Web, mobile, information, communication, voice services, both hardware and software) that must be made available in order for the scenario to work?*

   In this case the system should be able to connect a computer to the phone network and stream voice messages, and store incoming phone calls. The system should be able to work with an internet connection, but also without it, as this infrastructure is often lacking in rural Africa. A deployment diagram is given in Figure 39, showing the various interfaces and gateway. A simplified (non-formal) network diagram, sketched in Figure 42 gives a general idea of the set-up. A view of all development modules is given in Figure 37.

8. *Cost considerations: what are estimated associated costs (operational, investment, development, in/outsource) for the envisaged technology infrastructure and components? Who carries these costs?*

   The initial costs of the Tabale case are estimated as the costs of the platform and the initial installation. Recurrent costs are: the maintenance of the system, and phone costs for the NGO or extension worker. The initial development costs would be carried by the ICT4D project. The software would be made available as open source (free of license cost). The operational costs would in this case be carried by the NGO as part of their exploitation. (This section needs further elaboration, as will be discussed in Chapter 8.)

9. *Feasibility and sustainability: The following checklist of questions needs answers:*

   a) *What is the technical feasibility of the scenario (e.g. risk analysis, technical obstacles to overcome, system-level impacts)?*

      Technically the Tabale system would be simple and robust. The problem is the phone connection which has to be local (to allow local phone calls).

   b) *What is the business and (socio-)economic feasibility and sustainability of the scenario?*

      As a tool to communicate between an NGO and farmers, the feasibility and sustainability are well defined. The system saves time and is therefore useful and saves money.

   c) *What are possible goal conflicts and dependencies between the actors in the scenario?*

      There are no serious goal conflicts identified for this case.

   d) *Are there preconditions for the scenario to work, and is it sufficiently interoperable with the wider context in a business as well as technical sense?*

      The system runs on a platform that connects to a local phone network. This platform must therefore be available locally. The recipient users must have mobile phones.

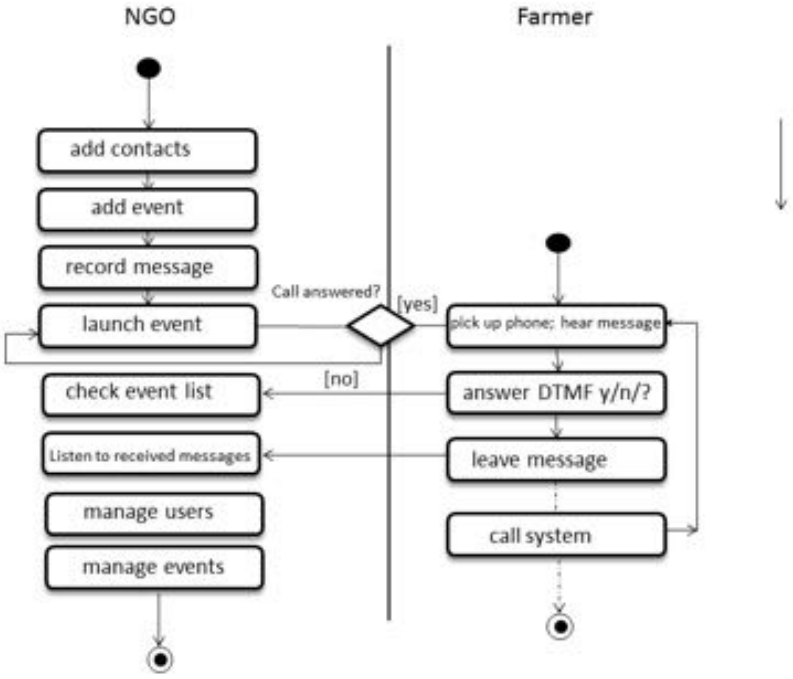

Figure 41: An example of a formal UML activity diagram for the mobile event organizer system. It shows the events and interactions in sequence, between the two user categories and the system.

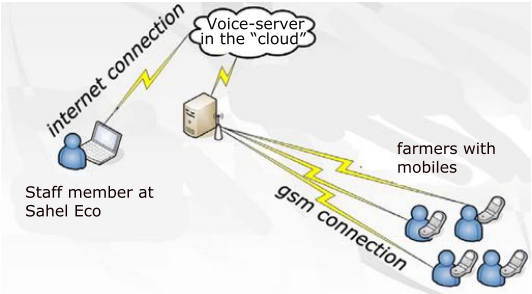

Figure 42: An informal model of the infrastructure needed for the mobile event organizer: a voice server connected to the Internet and to the mobile (gsm) network.

10. *Key requirements So-called MoSCoW list of requirements [317] (Must have, Should have, Could have, Won't have) as a starting point for further architecture design, and system and component development.*

    For the mobile event-organizer, Tabale, it is an essential requirement (a *must have*) that it has a Web interface where user profiles can be entered, including their phone numbers and language preferences and that a voice message can be recorded in several languages. It must be able to send the message to a number of phones at one button push: see Figure 38.

    Should have: the possibility for the user to reply and leave a message that is stored in the system and is accessible via the web interface. It could have an option where users could phone in. It will not have to rely on an Internet connection to reach the users, since there is no Internet in the villages. It will not use SMS to reach the users, because they are often illiterate.

6.4 SUMMARY

This chapter has presented a new method for elaboration of use case and requirements, the "structured narrative method". This method captures and structures key ideas and user stories. It enables to capture complex unstructured information and presents it in a structured format. It facilitates communication about requirements in a non-formal way, using narratives and storyboards, but also captures technical system specifications and represents the information through formal models.

This method is appropriate for ICT4D software development projects as it bridges the worlds of users and technical developers. Moreover, it also covers more than just the narrow technical system. It includes business requirements and information related to the local context – topics not commonly covered in mainstream use case and requirement analysis methods (see e.g. [122, 169, 181, 296]).

The structured narrative method is useful for ICT4D, but can also serve other software development projects, especially those situated in dynamic (complex) contexts or in projects in which communication between various stakeholders is cumbersome, due to e.g. large differences in backgrounds or world views.

7

ENGINEERING, DEPLOYING, EVALUATING IN A COLLABORATIVE APPROACH

Developing a useful and valuable system for people in a low-resource context requires multiple iterations of building, testing, and evaluating. Given special conditions that may exist in low-resource contexts – e.g. poor infrastructure, language, cultural differences between developers and users – this involves a broad interdisciplinary team, collaborating closely over a period of time. This chapter describes the case of a field pilot of the development and deployment of a voice-based market information system in rural Mali, aimed to support farmers and their emerging value chains. It covers the full lifecycle of software development of an ICT4D project, starting with context analysis, needs assessment, use case and requirements analysis, engineering, testing, evaluating, deploying the system in a real world production environment, and doing an impact assessment after some time. It shows how problem analysis is done iteratively, how the complexity of the local environment requires a non-linear approach to project management. All systems and sources developed during this project have been made available as Open Source. This aligns well with the sixth Principle for Digital Development: Use Open Standards and Open Source[1].

7.1 THE INFORMATION SYSTEMS ENGINEERING DIMENSION IN ICT4D

This chapter presents the story of an ICT4D project in rural Mali that followed the collaborative approach, as described in the previous chapters. It started with a context analysis and needs assessment with local farmers and radio stations. During deployment, several unexpected events occurred that required action, and deviation from the original project plans, to make things work. E.g. we had to build speech technologies in local African languages, which was not foreseen. The infrastructure provided by the telecom provider proved not to be sustainable after the end of the project, so other solutions were to be sought for long-term sustainability. User impact evaluation yielded both unexpected outcomes and positive impacts. There were several take-home lessons for ICT4D researchers and developers. This case shows how ICT4D development works in a complex context, and how collaboration with local users, many iterative cycles, flexibility of the team and adaptation to the local context are required and can be practically implemented. A large team contributed to this unique project.

1 See: https://digitalprinciples.org/, (accessed 31-07-2019)

Figure 43: Needs assessment meeting between developers and farmers in Tominian, Mali, 17 November 2011. Photo: Bruno van Moerkerken.

7.2 CASE: BUILDING SYSTEMS FOR FARMERS IN MALI

In the framework of a European ICT research project named VOICES[2] the W4RA team and partners did a 30-month field experiment, which led to deployment of a voice-based market information system in rural Mali. The interdisciplinary, multicultural team[3] in this project consisted of researchers and ICT developers: speech technologists, web developers, requirement engineers, information analysts, but also: regreening experts, key-users, business partners and local farmers. A full technical design of this system has previously been published [131, 130] and can be seen in various documentaries[4]. The requirements analysis and technical development of this system are more extensively described in the PhD thesis of W4RA team member Nana Baah Gyan [130].

7.3 CONTEXT, NEEDS, AND USER REQUIREMENTS

A 12-day roadshow through rural regions in West Africa (by bus through Mali, Burkina Faso and northern Ghana), marked the start of the VOICES project in January 2011. We held interviews and focus group discussions with farmers in small villages. We learned about the importance of forest products – which result from large-scale regreening – for farmers in Mali. This chapter briefly describes the context, the needs assessment,

2 This was done in the framework of the VOICES research project, funded by the EU in the FP-7 program. See also https://w4ra.org/publications/voices/ ((accessed 31-07-2019).)

3 From SBC4D, VU Amsterdam, 2CoolMonkeys, Web Foundation, North West University, South Africa, Sahel Eco and other stakeholders.

4 e.g. http://w4ra.org/the_making_of_radiomarche (accessed 31-07-2019)

the requirement analysis and iteratively building, testing and evaluating of a market information system that aimed to help farmers sell their forest products. This is what we learned about the emerging so-called agro-forestry value chains in rural Mali:

In years of low rainfall, when normal crops (cereals, cotton, and vegetables) have low yields, farmers are vulnerable for food shortages. Tree products can be a valuable additional source of income, as the trees are more resistant to drought and their growth cycles are different from the cultivated crops. Tree products such as baobab leaves, honey, shea nuts, grains and fruits, are available at different times of the year.

For example, one of the forest products which is widely used by the rural communities in Mali[5] is the nut from the shea tree (Vitellaria paradoxa). Collection of shea nuts and local production of sheabutter is done by women. Sheabutter is sold at the local markets, as a kitchen consumable, used for baking. Sales of sheabutter can increase the income of women and leave their households less vulnerable to crop loss and dry seasons. Another forest product, mainly collected by women, is neré. Firewood and other non-timber forest products, such as seeds, nuts, fruit and honey, are easy to harvest and manage on the long term. By transforming these products (into sheabutter, soumbala, purified honey, charcoal etc), the farmers can improve their income.

To support farmers in Mali, local NGO Sahel Eco started a project to help improve the production and commercialization of tree products[6]. Farmer women who harvested the nuts of the shea tree, were trained in simple, affordable processing techniques to improve the quality of home-made shea butter. Bee keepers – usually men – were trained by Sahel Eco to increase quantity and quality of honey. However, selling tree products is difficult for the farmers who live remote from the markets; the local roads are in bad condition and transports are expensive.

FOCUS GROUP WITH FARMERS IN SÉGOU In November 2011 our research team, consisting of fifteen international and local participants, met eight farmers (three women, five men) who live in the Ségou district and produce tree products: honey, shea nuts & butter, tamarind, and saban (a fruit). The meeting took place under a tree and was in the Bambara language, simultaneously translated to French and English by various participants.

Farmers told us that formerly, farming and trading was done individually, without success. Two-three years ago, these farmers joined forces and formed small farming & trading cooperatives, called *bemba*. Together they started to improve the quality of the (tree) products: shea butter, shea soap and honey. There are now 6 bemba of 10 farmers each, organized per product. This new organizational structure had greatly improved trade and their negotiating position. Formerly, women farmers, who are mostly illiterate, were often tricked by buyers.

5 And other countries in the Sahel.

6 Sponsored initially by TreeAid in the Tree4Change project.

We asked them about the use of mobile phones. They told us the phone is an important business instrument. Every farmer owns or has access to a mobile phone. Phones are personal – not shared by a group – but can be borrowed. Some women do not own a phone themselves, but use their husbands' phone. This is awkward because the men often travel and the wives stay at home. Expenditure on mobile calls is 2000 to 3000 fCFA per month[7], mainly on commercial calls to customers.

Three women told us they used the phone for trading e.g. phoning buyers or NGO representatives. *Beeping* (ringing and quickly hanging up to avoid having costs) to potential customers is not usual. The typical phone usage is (i) to keep in touch with family and friends, (ii) using the calculator, (iii) using the built-in phone clock. SMS text messaging is not popular in this group. Young people are sometimes asked for help (although the farmers in this group know how to use SMS). A female participant said 'SMS is for people who can read and write'.

In terms of mobile network coverage, some of the villages e.g. Sibila, near Ségou, did not yet have a mobile network. Near the road the mobile network access was reasonable, but only at night. Farmers mentioned that bad network connection wasted their airtime, since many calls failed. Farmers knew how to top up their phone balance[8]. Sometimes they asked the airtime reseller to assist with topping up. There was no electricity in the villages. Only 12 volt batteries and solar panels. Mobile phones are recharged in the local shop, for 100 fCFA.

The farmers expressed difficulties in finding customers. Still, they were not sure if they would pay for an ICT system that would broadcast their product offerings on the radio. Their production could be increased, as human labour is not the restricting factor. The problem is the access to customers, as well as the transportation of the goods. Individual production is too small for 'big' customers, such as international companies. The farmers thought that the local market would be the best place to find customers for their products.

Based on this meeting and other workshops during two road shows in Mali between January 2011 and November 2012, three use cases were selected which were further elaborated[9].

RURAL COMMUNITY RADIOS AS RURAL INFORMATION HUBS In January and November 2011 we also visited a few radios. These are important information hubs in rural Africa, in the absence of the Internet and other media. Since radios could be potential business partners for the envisaged ICT deployments, we visited and interviewed the radio journalists. This is what we learned about rural radios in Mali:

7 This is about 3 to 4,50 EUR per month. This may represent 5 to 10 % of an average monthly income in this rural region of Mali.

8 This is done using the USSD channel of the mobile network.

9 The other two use cases: Tabale and Foroba Blon are discussed in resp. Chapters 6 and 8.

Some of the community radios in rural Mali have computers and an Internet connection, some have computers and no access to the Internet and some have no computer facilities at all[10]. These rural radios reach between 80.000 and 150.000 listeners, with a radius of 100 up to 200 km. Rural radio stations create their own localized programs by broadcasting local and regional news, music, informative programs, round table programs and paid announcements. All radios we visited had mobile access. We met the following radios:

- Radio ORTM Ségou, a state-owned radio with only computers and a 2 Mbps fixed line (ADSL) Internet connection. Radio ORTM Ségou broadcasts programs in French and Bambara, the most widely spoken language in Mali;
- Radio Moutian, in Tominian, a private radio financed by paid announcements broadcasting and private gifts. Radio Moutian has a computer but no Internet. Programs are mainly in Bomu, a local language of the Tominian region;
- Radio Seno, Bankass, a private radio. There are no computers, no Internet. The radio has many listeners in the region. The main language is Dogon.
- Radio Sikidolo, Konobougou, a private radio with computers. They use a Dongle to access the Internet over mobile network (this is very expensive). The language is Bambara (although the journalist Adama Tessougué is from the Dogon region).

In 2011, these radio stations were still using old, analogue equipment, such as tape recorders. The information they broadcast was not stored or kept for access or reuse. The radios did not have ways to manage or reuse the spoken radio content. We brainstormed that combining mobile phone and radio would give opportunities for innovative data services. E.g. radio listeners phone to the radio station and leave voice messages that they want to have broadcasted, or react to popular radio programs leaving news, opinion, regional information etc.

USE CASE ANALYSIS OF MARKET INFORMATION SYSTEM To help improve the sales of tree products for the farmers, a development project was set up by Sahel Eco in 2010[11] in the *Cercle de Tominian*, south-east Mali. The project organized radio advertisements to improve sales of the farmers' forest products on the radio. For this pilot, they selected representatives from nineteen villages in the district of Tominian, from the cooperatives of Hirosin and Farakunna, who were requested to send weekly detailed offerings of the available forest products to Sahel Eco. The workflow was as such:

10 This can change over time, this particular information was collected in February 2012.
11 Part of a project named Village Tree Entreprise, financed by UK agency Tree Aid.

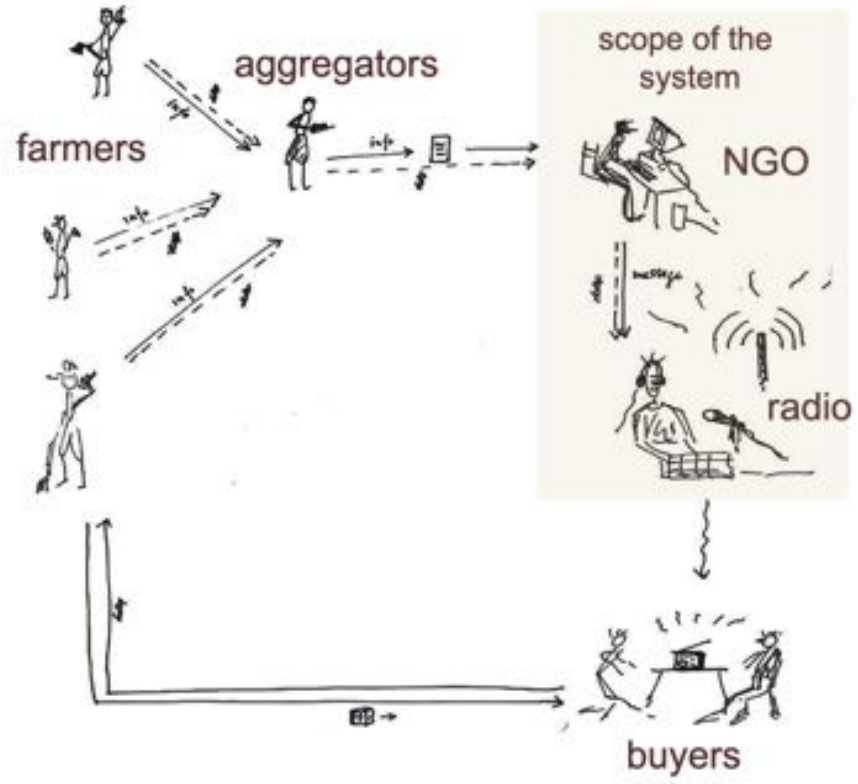

Figure 44: Sketch of the complete workflow for the market information system including the scope of the envisaged system (marked by the grey area). This sketch proved very useful in various occasions for understanding the total workflow, including the scope of the envisaged system.

ORIGINAL WORK FLOW OF USE CASE Amadou Tangara, the *chef d' antenne* for Sahel Eco in Tominian, aggregated product offerings of forest products from farmers of 19 villages on his laptop, and sent this information to four community radios, every week. The radio stations broadcast the offerings as paid advertisements. Broadcasts by the radio, cost 1000 fCFA[12] per minute airtime for non-commercial clients. This was paid by Sahel Eco during the pilot.

The offerings were entered in a table format (Excel sheet) on Tangara's laptop. He included the product names, amount available per product (in kg or liter), price per unity, quality of the products (e.g. filtered or unfiltered honey), contact name and phone number of each producer.

The idea of making the radio announcements was promising, but the workflow was time-consuming. Firstly, Tangara could not send group messages to the farmers to aggregate the offerings, because they (evidently) did not have internet. So, he had to

12 Local currency: 656 fCFA is 1 EUR.

collect all the information individually and aggregate the 19 different offerings from 19 villages and send it to the radios. (These product offerings were sent to Tangara by SMS, for which the contact persons had received a small training by Tangara). An ICT solution was requested, to improve this workflow.

Based on the input, a semi-formal model of the workflow was sketched, to make sure the whole process was well understood. The sketch Anna made hastily in my notebook, is given in Figure 44. It was decided that we would leave the 19 farmers outside the scope of the system, and concentrated on developing a system to facilitate the work of Tangara and the radios. The scope of the envisaged ICT system is marked by a grey box in Figure 44.

To understand the roles of radios in this pilot, we talked with ORTM Ségou's journalist Fousseyni Diarra, and Radio Moutian's journalists Gustave Diallo and Bakary Dembelé from Tominian and we visited Radio Seno in Bankass. At radio Moutian and at radio Seno one had to go to a local cyber café to download Tangara's product offerings spreadsheet, which he sent to them by email. The offerings – in this project they were referred to as *communiqués* – were read out by the radio journalists and broadcast in local languages. In Ségou the language was Bambara, in Tominian this was Bomu, in Bankass and Mopti, this was Dogon. The task was time consuming for the radio staff, who had to read this boring list of phone numbers, prices and products, and repeat this many times. It was also prone to errors.

We jointly decided, (after a process of needs assessment and use case elaboration, as previously described [130]), to design and build the above use case, because it was promising for the farmers and it would support regreening initiatives in Mali.

Speech technologies were chosen to generate spoken communiqués from the (textual) market offerings. This was useful for the radios, because now they could broadcast the same automated voice messages several times. The automatically spoken communiqués with market offerings could only be accessed by mobile phone by the participating radios who did not have an Internet connection in their offices. So this was an important requirement – a "must" in *MuSCoW* terms (see Chapter 6).

A web-based interface with pull-down menus was built, where Tangara could easily enter the project offerings he received from the farmers. A mockup was designed (by Chris van Aart and Nana Gyan) to show Tangara the look and feel of the web interface (see Figure 45). For monitoring and evaluation purposes, a database was built, to organize and keep track of all offerings over time. (As previousy Tangara used to store the data in an Excel sheet.) This made it possible to create aggregates and reports, and keep track of the sales and offerings.

The created communiqué must be issued through voice in French and Bambara language. Language support for Bomu, to create voice messages in this language, was considered important for the region of Tominian but this was temporarily postponed.

Additional radio requirements were: the audio of the voice communiqué must be of a quality good enough for broadcasting on the radios. The voices used to generate

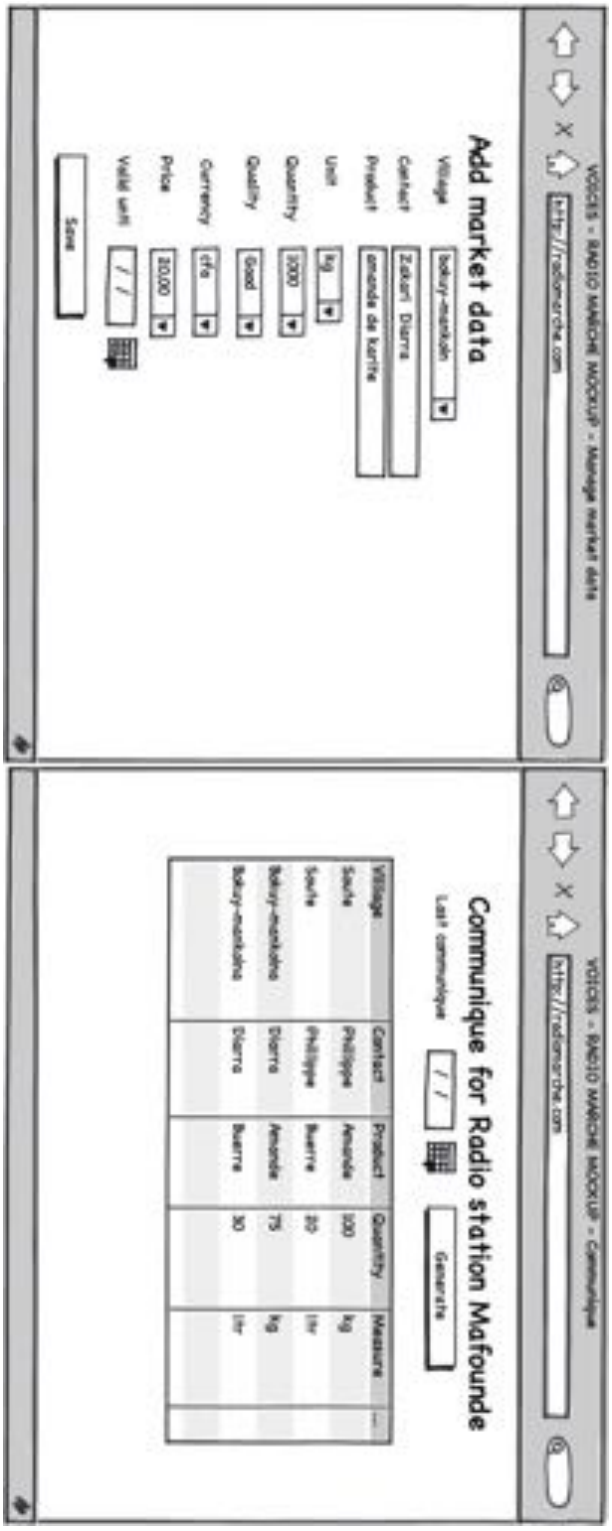

Figure 45: Mockup for RadioMarché, pictured by Chris van Aart and Nana Baah Gyan, to give users an idea of the envisaged web interface.

Figure 46: Three members of the W4RA team (RadioMarché logo on the T-shirts) in Burkina Faso for a co-creation workshop. Logo designed by Victor de Boer. The small cartoon-figure is named Monsieur Mouriba. Photo by Bruno van Moerkerken, July 2014.

the message must sound familiar (local accent) in this region. Given the fact that the radio journalists' voices were known and appreciated in the regions, the generated communiqué should be built using the journalist's own voice. Each of the four radios participating in the pilot should be able to access its own generated voice communiqué, by dialing a certain phone number.

The name given to the system was RadioMarché. A logo was designed by Victor de Boer showing the three concepts of the system: market, radio, mobile phone. The national colors of Mali: yellow green and red were used. The little fellow is named Monsieur Mouriba. The name was given by Amadou Tangara. Figure 46 shows three members of the W4RA team, with RadioMarché T-shirts.

7.4 ENGINEERING THE SYSTEM IN A COLLABORATIVE WAY

Based on the requirements collected during the various meetings with the key-users, various UML models were designed[13] according to the format as described in Chapter 6.

When the first demos of RadioMarché, spoken in French, were presented to the users, we received feedback with respect to language: to have a real impact in rural areas of Mali, RadioMarché must be able to generate communiqués in local languages. This hard requirement was a complicating factor for the developers' team. No one had proficiency in these languages. But since this was a critical success factor for RadioMarché,

13 This is part of the development (a number of needs assessment workshops with local farmers and the use case and requirements) has been extensively described in the thesis of Nana Baah Gyan [130].

we jointly decided to build language interfaces in Bambara and Bomu, two local languages in Mali. The voice applications were built with recordings, translations and help of local radio journalists and Sahel Eco staff members.

7.4.1 *Building and testing the speech interface*

The RadioMarché TTS takes textual information as displayed in Figure 49 as input and produces an audio file that can be broadcast to radio listeners as output. The resulting communiqué is accessible by either (i) phoning the system, or (ii) downloading the audiofile from the website.

For big, 'normal' languages such as English, French or Chinese, fully operational TTS systems exist, and are available from the web. However, this TTS system for Bambara, Bomu and Malian French, was specifically developed by speech technology expert Etienne Barnard and his team from North-West University in South Africa, together with Stéphane Boyera from SBC4D. This was done at the request of the users in Mali, because of the need to contextualize the communiqués.

To do this, a Text-To-Speech (TTS) module was built for RadioMarché[14]. This was done using so-called Slot & Filler Text-To-Speech method. This method and system, which is developed specifically for under-resourced languages, uses a limited dictionary, with words from a specific domain only[15]. A toolkit for text processing and speech segmentation enables rapid development of a TTS for new languages[16].

The first version was only in the local French dialect. Similar systems in the Malian languages of Bamako and Bomu were developed, and evaluated in a later cycle.

According to the needs of the local stakeholders, we did not use standard French voices – which would have been easy, because automated voices are freely available on the Web, also in standard French[17]. Instead, we had to record local utterances, spoken by radio journalists. Radio journalists Fousseyni, Gustave Diallo and our key-user Amadou Tangara translated the text, necessary to generate all possible communiqués, and recorded the messages in French, Bambara and Bomu. From their recordings the automatic speech generation was built. Evaluation of the speech generator took several cycles, which we did with the partners during our trip in Mali. I wrote the following notes in my trip report of November 2012:

> *"We evaluated the first version of the TTS for Bambara with two native speakers: Fousseyni Diarra and Amadou Tangara. The written text contains a few grammatical errors, which*

14 Parts of this section are from an internal report by Etienne Barnard, who built the TTS with Stéphane Boyera.

15 See also the master thesis by Justyna Kleczar, VU Amsterdam, July 2017 http://tinyurl.com/Kleczar-Slot-and-FillerTTS (accessed 31-07-2019)

16 Source: E. Barnard and F. C. Pinto. Proposal documents to standards committees. VOICES project deliverable D3.1, 2013.

17 We note that "Malian" French and "French" French are not fully the same.

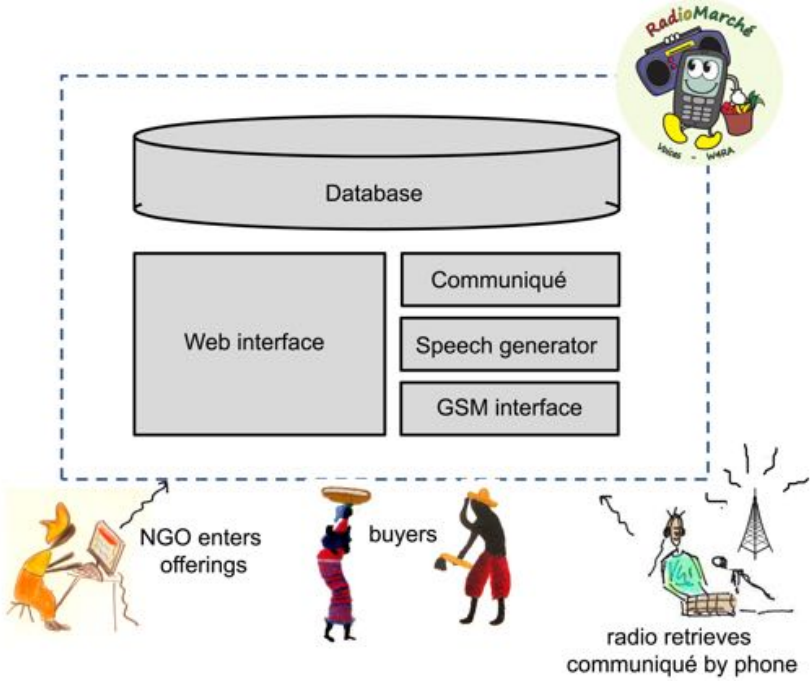

Figure 47: Conceptual design for RadioMarché, showing the components of the system; by Victor de Boer and Anna Bon; RadioMarché logo designed by Victor de Boer.

> *they corrected for us. The two evaluators found it possible to understand the spoken communiqué. However, this quality of speech is still not good enough for broadcasting. There were not sufficient pauses between words and sentences. The intonation sounded unnatural. The same was done for the Bomu language TTS. The written text contained grammatical errors. Native speaker Bakary Dembelé corrected this text for us. Five Bomu native speakers (farmers) commented on the TTS generated Bomu communiqué: They found it possible to understand it, however, the communiqué did not sound completely natural, 'it is like the speaker is not breathing between the sentences'. Still, the voice quality was found acceptable."*

Feedback was processed and a new version was released and deployed for RadioMarché. Local users helped to improve the interfaces, by evaluating the quality of the automatically generated speech communiqués. In order to gain an improved understanding of the experimental Text-to-Speech (TTS) systems, early in the development process of RadioMarché, the first cycle of acceptance studies was performed in April 2012 in Mali, at the office of Sahel Eco. This is a summary of the technical evaluation of the VOICES project, by Etienne Barnard and Mary Allen:

During user acceptance studies the usability and desirability of speech technology was evaluated by the target populations. This first cycle evaluated the intelligibility

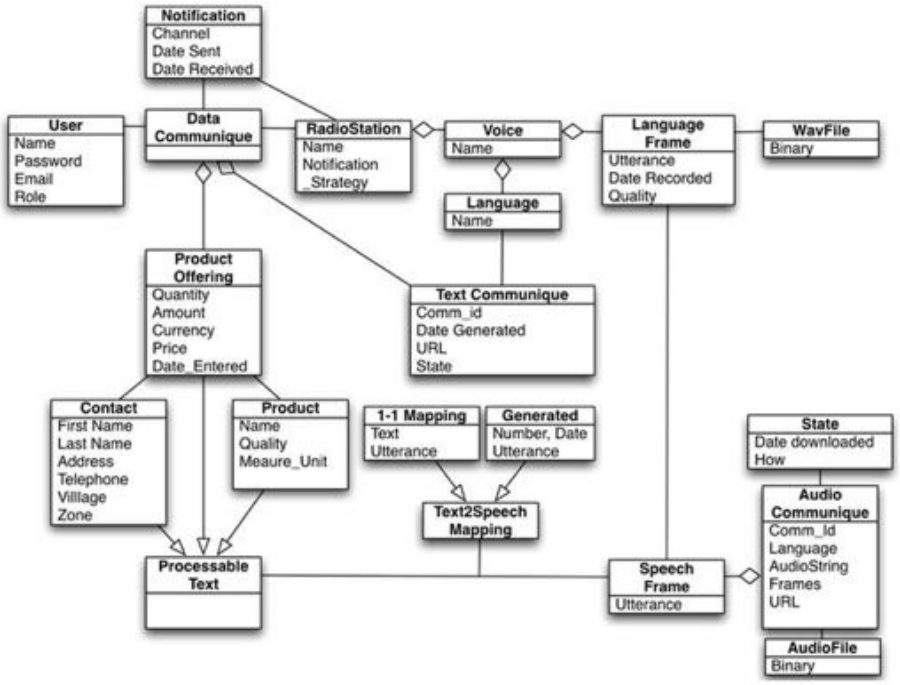

Figure 48: A (UML) class diagram for RadioMarché showing the classes, attributes, their relationships and dependencies, as technical specification for the developers. After a model by Stéphane Boyera and Nana Baah Gyan.

and naturalness of our initial set of slot-and-filler text-to-speech (TTS) systems, which function in West African French[18].

For the evaluation and user acceptance of the TTS voice system, ten people were invited at the office of Sahel Eco in Bamako. The respondents were asked to listen to audio files containing two versions of exactly the same bulletin. One version was the automatically generated communiqué and the other was a natural voice reading out the same text. Both naturalness and intelligibility were investigated. The users were requested to give their feedback on the speed of the speech, if it was understandable and if it sounded natural. Quoting Etienne Barnard[19].

> *"The first version ('recorded speech') had been recorded by one of the radio journalists. The second ('generated speech') was created with our system (Slot-and-Filler TTS). Ten listeners from our intended target population (residents of Bamako who understand French) were invited by Sahel Eco to act as respondents in the usability test. These respondents (4 females and 6 males) were all adults with at least a basic level of literacy in French, but were not pre-screened in any other way. Each respondent listened to both the generated and the recorded versions of the bulletin (half the respondents hearing the generated version first, and the other half the recorded version). After listening to each bulletin, each respondent was asked to complete a questionnaire that was designed to assess the intelligibility and naturalness of the speech that had been presented. Upon completion of the second questionnaire, the respondents were also asked to compare the two systems, and to provide any additional feedback according to their own preferences. As expected, the users generally preferred the normal speech. However, all ten respondents found the TTS-generated speech either 'very easy' or 'somewhat easy' to understand. The respondents generally found the speech rates acceptable, for both recorded and generated speech. The respondents who were not perfectly happy with the speed were almost equally likely to prefer slower and faster delivery – thus suggesting that the current rates are the best compromise available."*

Although the acceptance tests for the speech technologies were limited in scope, they provided credible answers if the respondents find the current TTS system intelligible or unnatural. The user study confirmed the viability of the basic approach to generate speech. Moreover, this result gave us the green light to proceed with this aspect of the project, as previously planned.

It was reassuring that this experimental approach seemed to elicit the information that we desired without any unexpected surprises. These conclusions allowed us to proceed with confidence in the development, deployment and assessment of additional S&F TTS systems. A similar approach was used in a later stage to assess the Bambara speech-recognition system.

18 Source: Internal project report VOICES D3.3, by Etienne Barnard, 2013.

19 Source: Internal project report and personal communication with Etienne Barnard for the VOICES project 2011-2013.

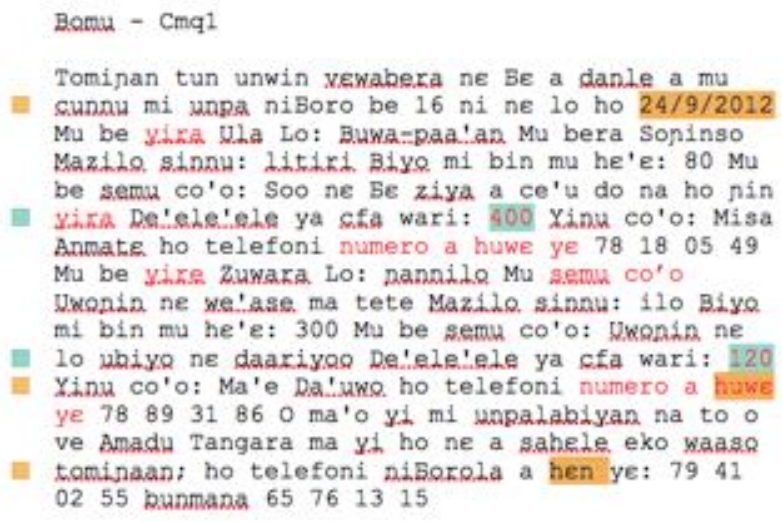

Figure 49: The text of the communiqué in Bomu, as broadcast by Radio Moutian, translated and reviewed by radio journalist Bakary Dembelé, from Radio Moutian.

7.4.2 *Users testing the mobile interface*

In November 2012, production prototypes for RadioMarché and Tabalé (see Chapter 6), were ready to be shown to prospective end-users: two NGO-staff members Amadou Tangara and Drissa Gana and five farmers from a small rural community near Tominian. The prototypes were improved according to their feedback. The farmers evaluated especially the Tabale system (which is described in Chapter 4).

During the evaluation meeting we did a quick recapitulation of the original legacy workflow – what people used to do before Tabale – and then we explained what the designed system was envisaged to do. We tested the system, and evaluated its functionality, the user interface for different roles, and collected all feedback from the users. Not all users in the evaluation were French speakers, so there was some translation done between French and Bomu, the local language in the Tominian region. The use of DTMF on the mobile phones (press 1 for yes, 2 for no etc), the navigation of the voice-menu, and the quality of the pre-recorded voice messages were tested. The respondents gave feedback on several aspects of usability. All their feedback was collected and the system was improved and released based on their comments. After the users' evaluation of the first cycle, and having fixed the bugs and added new functionality, a new version was released.

7.5 DEPLOYING A SYSTEM IN A LOW RESOURCE ENVIRONMENT

It is challenging to deploy an ICT system successfully (and ensure its sustainability), when the local Internet infrastructure is unreliable, extremely expensive, or totally absent. As this is the case in many regions in rural West Africa, we had two possible options for the local deployment of RadioMarché: (i) to use a cloud solution, i.e. a server accessible through an Internet connection (while this may be unreachable or too expensive for local users); (ii) to build a local infrastructure based on small-scale hardware solutions (whereas the technical solutions may not yet be proven technology).

7.5.1 *Large-scale server in the cloud*

For our RadioMaché pilot, Orange Labs (one of our project partners in the EU FP7 VOICES project[20], developed an open source voice platform. The platform, which became operational in 2012, was named *Emerginov*[21]. The platform was available without costs for the users during the project period of VOICES. After the end of the VOICES project, Orange closed the Emerginov service. The consequence was that the RadioMarché and Tabalé systems were no longer available for the local users. (This is a typical example of the unsustainability of donor-funded ICT4D projects, in combination with lack of interest in longer term results by some of the project partners.)

7.5.2 *A small-scale local server as an alternative*

Aware of the need for a telco-independent voice platform in rural Mali, (to be independent of the current platform offered temporarily by the telecom operator) and the wish of local users to continue the voice-based services after the project period, in 2012 the W4RA team started development of an alternative voice server for phone and Internet access in low-resource environments. We used small inexpensive hardware, in a research project which was named "Downscaling the Web"[22].

After several iterations, in May 2015 a prototype voice server for rural development in Africa was released and given the name *Kasadaka*, a Ghanaian name which means "talking box"[23] The Kasadaka's first deployment is a rapid prototyping platform. It allows quick and efficient needs assessment and requirements elicitation during the workshops in Africa. Its hardware[24] is small (the size of a creditcard), and inexpensive (about 60 EUR). It can endure rural conditions: heat, dust, as it does not have spinning

20 http://mvoices.eu (accessed 31-07-2019)
21 See: http://emerginov.org (accessed 31-07-2019)
22 Initiated by W4RA researcher and colleague Christophe Guéret, see https://worlswidesemanticweb.org (accessed 31-07-2019)
23 A full technical description of the Kasadaka can be accessed at http://kasadaka.com (accessed 31-07-2019)
24 Raspberry Pi: https://tinyurl.com/y7kopfvd, (accessed 31-07-2019)

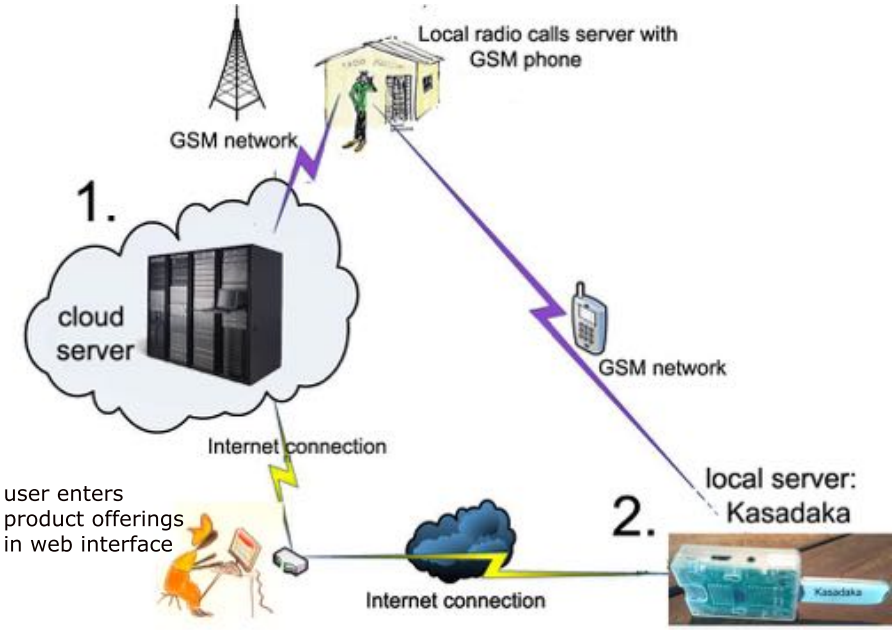

Figure 50: Two options for a voice-server under rural conditions: (1.) a "big server" in the cloud or (2.) develop a "downscaled", inexpensive solution/infrastructure, and deploy it locally. This is the "Kasadaka" project, which is currently (2019) still being developed by the team.

disks. It is a low-energy consumer and can be used with a small solar battery. It can (if available) be connected to the internet using a wifi or a fixed internet connection. It can be used stand-alone. It has a dongle with a SIM card to allow access to the phone network through (GSM) phone. The server is powered by the free and open source framework Asterisk[25], a framework for building (voice-based) communications applications.

The Kasadaka server offers API's for applications built in e.g. PHP, a server-side scripting language for making dynamic and interactive (including voice-based) Web pages and interactive voice dialogues, and for VoiceXML[26].

The small-scale Kasadaka voice-platform is an ongoing research project by researchers and students[27] from the W4RA team at VU Amsterdam. Kasadaka aims to serve the needs of users in low-resource contexts. It supports development and deployment of speech-based mobile applications. A software development kit for Kasadaka (SDK), that facilitates development of voice applications (for people with limited programming skills), will be further developed and tested under rural conditions in the coming period[28].

7.5.3 *Which server should be used when?*

Figure 50 shows two possible infrastructure solutions: (i) one based on an large cloud server connected through the internet (ii) a local server infrastructure based on unexpensive hardware. Which one is best suitable depends on the scale of the deployment. The small hardware solution has only one or two available phone lines, so it can handle two concurrent incoming calls, thus limiting the size of the service.

The cloud server is an expensive solution, especially for users in rural Mali. The costs of hosting a server in a datacentre, in combination with a fixed-line connection to the local phone network are far beyond what a small ICT entrepreneur or radio station in Mali can afford (> 1500 EUR per month is an estimate of the hosting costs including a fixed phone line for 32 concurrent lines, in Bamako, Mali). In the stage of piloting and testing, the small hardware solution is an inexpensive and robust solution for the voice-platform. A more sustainable technical and business solution is currently being studied/developed[29].

25 See Asterisk: https://www.asterisk.org/ (accessed 31-07-2019)

26 VXML is an official W3C standard, see: https://www.w3.org/TR/voicexml30/, (accessed 31-07-2019)– VXML is the standard markup language for voice browsers specifying interactive media and voice dialogues between humans and computers.

27 André Baart, Victor de Boer, Francis Dittoh and Christophe Guéret are the developers of Kasadaka.

28 See: Master thesis by André Baart, VU Amsterdam, December 2017, https://tinyurl.com/kasadaka-sdk-a-baart, (accessed 31-07-2019).

29 By the W4RA team at VU Amsterdam, in close dialogue with Radio Sikidolo and other stakeholders in Mali.

The outcomes of the RadioMarché deployment with respect to the underlying infrastructure and voice platform have given new insights on various problems of ICT4D which are widespread, highly relevant, but not yet solved. This leads to new research questions, for example with respect to (i) technical infrastructure (cf. the Kasadaka project), (ii) further development of speech and voice technologies and (iii) business/financial aspects of sustainability of ICT4D. These topics are currently subject of ongoing research at VU Amsterdam, in the framework of the W4RA research programme on "knowledge sharing for the rural poor".

7.6 COLLABORATIVE IMPACT EVALUATION

The RadioMarché system turned out to be a promising step forward and was highly valued by local users and beneficiaries. In October and November 2012 participatory impact evaluations were performed for RadioMarché[30]. Five radio stations[31] were visited and feedback was collected with written questionnaires[32]. Farmers who participated in the pilot and buyers, triggered by the RadioMarché announcements, were also interviewed. The impact evaluation had some unexpected outcomes, that could not have been planned in advance.

MONITORING THE PILOT During the RadioMarché pilot, monitoring activities were done by Sahel Eco to assess the number of product offerings, sent by the 19 contact persons from the villages, the number of products offered (see Figure 51), the number of broadcasts made by the radio, the amount of sales effectuated. The last indicator was assessed by interviewing the farmers regularly, through questionnaires to the radio stations on the usability of the system, and questionnaires to potential customers. A logging system to monitor the activities on the platform was available for this monitoring. An interview was held with key-beneficiaries Zakary Diarra, producer and reseller of honey, and Naomi Dembelé, producer of shea butter. With their consent these interviews have been placed online[33].

UNEXPECTED OUTCOMES The broadcasts of RadioMarché in 2011 and 2012 created a demand of honey that could not be met by the producers, according to the radio journalists[34], so they requested Sahel Eco to stop the broadcasts of communiqués for honey, unless stock would be readily available. They suggested to create sales points

30 For the evaluation report see: http://tinyurl.com/W4RA-Web-of-Voice-pdfs (accessed 31-07-2019)

31 Radio ORTM Ségou, Radio Sikidolo (that joined the project in 2012), Radio Koutiala, Radio Mopti, Radio Seno Bankass.

32 A full evaluation of the RadioMarché system, deployed in rural Mali, can be found in http://tinyurl.com/W4RA-Voices-D5-4p.42 (accessed 31-07-2019)

33 http://tinyurl.com/W4RA-Naomi-interview-2013 (accessed 31-07-2019)

34 In interviews with Fousseyni, Bakary and Tangara in November 2012.

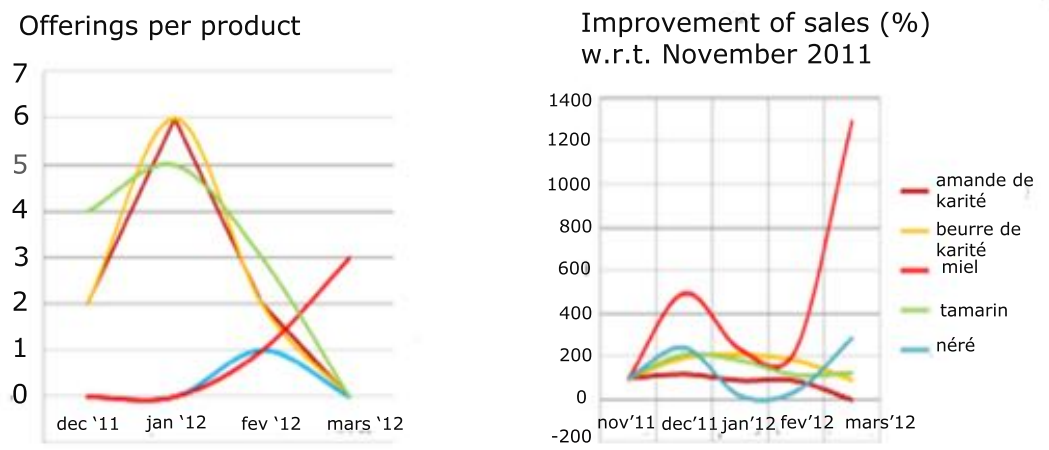

Figure 51: The number of product offerings, sent by the 19 farmers per product (left); the relative increase of sales in relation to November 2011 (right). By Amadou Tangara and colleagues. Courtesy of Sahel Eco.

for honey in Ségou and Tominian, to take the burden off the radio stations, who are called frequently by buyers interested in honey.

The broadcasts had a tremendous effect, according to the stakeholders. Sales of honey went up. Farmers, who had, through this system, started to collect and sell more honey, could not meet the increased demand for honey. More farmers started to produce honey in the villages. A sales point for honey was set up at the branch office of Sahel Eco in Tominian [35].

Zakary Diarra was one of the honey producers, from the village Bokuy-Monkuina, in the Tominian district, who benefited from RadioMarché. In an interview he said: *"I now sell 200 liters of honey. With RadioMarché, after the broadcast on the radio, I was able to sell all of my honey. I am now able to pay schooling for my four children and I could even buy a cart and a donkey, last year. People call me now So Zakary, which means Zakary of honey"*[36].

Naomi Dembelé, a women farmer from the village Sira, who produces shea butter, said in an interview to me: *"Thanks to this system we, the women who produce shea butter, are known throughout the country, and whenever there is a demand for shea nuts people will come to me. I am proud that I am known across the country."*

The demand for neré seeds was increased as well. However, demand for shea butter did not expand in the same way as honey. The packaging and transport of transformed products remained a difficult issue. According to Sahel Eco director Mary Allen, this pilot showed that agro-forestry value chains have potential, but need better organization, especially for certain products which have a lower local demand. In September

35 Les TICs dans les chaines de valeur agro-forestières. W4RA Working Papers 2014-1 http://tinyurl.com/y7xszbkj (accessed 31-07-2019)

36 See: http://w4ra.org/interview-with-zakary-diarra-beekeeper-in-mali/ (accessed 31-07-2019)

Produits	Quantités vendues					Total vendu	Prix par unité moyen	Montant (en fCFA)
	Nov. 11	Déc. 11	Jan. 12	Fév. 12	Mar 12			
Amande de karité (kg)	12 000	14 330	10 845	10 595	0	35 770	160	5 723 200
Beurre de karité (kg)	1040	2 021	2 171	1 904	951	7 047	1 000	7 047 000
Miel (l)	300	1 491	706	709	3 880	6 786	2 000	13 572 000
Tamarin (kg)	2 100	4 415	3 865	2 390	2 610	13 280	250	3 320 000
Néré (kg)	350	840	60	135	993	2 028	450	912 600
TOTAL GENERAL en francs CFA								30 574 800

Figure 52: Monitoring of the sales of forest products was done during the RadioMarché pilot. Diagram: courtesy Sahel Eco, internal project report 2013. By Amadou Tangara.

2013 Sahel Eco and farmer women started to engage transporters and to package shea butter in smaller quantities, to try to improve the local value chain for shea butter.

RadioMarché increased the sales of honey in 19 villages in the Circle of Tominian. It also brought new ideas how to set up local businesses in non-timber forest products. Farmers who benefited from the increased sales were very pleased with the system, and reported various benefits, some of which are difficult to quantify (however, not less important as a project outcome), such as "increased status in the village".

For the NGO the pilot made clear that various tree products in the region (e.g. sheabutter) need more elaboration, and more organization, to increase sales. In the case of the sales of honey, RadioMarché turned out highly valuable. For shea butter this was much less the case. This made clear to Sahel Eco that development of new value chains for sheabutter would need a different approach. They decided to take action and get a better understanding of issues related to transport, packaging of the product, choice of local market, marketing (pers.comm. Mary Allen, Amadou Tangara, Madeleine Dembelé, September 2013).

RE-USING THE SYSTEM FOR A DIFFERENT PURPOSE Based on the increased demand of honey and other tree products, Amadou Tangara, in 2013 and 2014, (one year after the end of the formal pilot) started to re-use the Tabalé system[37] to organize group sales for honey. Whenever a customer announced himself in Tominian at the Sahel Eco branch office or at the radio, with a large demand, Tangara used Tabalé to request farmers in the environment (whom he knew), to reply how much honey they could deliver. This was an unexpected use of the Tabale system, and shows its applicability

37 Described in Chapter 6.

for a different purpose than for which it was originally designed and built. This is an example of the general observation that adaptation of innovations by users is one of the characteristics of *real* innovation [263].

DISSEMINATION In 2014, farmers in the Yatenga region in Burkina Faso, after a presentation by Amadou Tangara, requested a version of RadioMarché. This should be revised, as the local language here is Mooré, and the products offered by the farmers are different. Five journalists from radio stations in the Yatenga and Zondoma region in Burkina Faso helped us to translate and record the new voice-dialogues in local Mooré language, in July 2014, for the local contextualization of RadioMarché. The name in Burkina Faso, according to the farmers, would be *Raas Kibaya*, market information in Mooré language. This project in Burkina Faso is still ongoing, in 2018.

TIME AND COSTS The RadioMarché project was sponsored during a limited period (36 months)[38]. During this period the farmers received the system without payments. The ICT systems were continued after the VOICES project[39], because of the great interest expressed by the local stakeholders (farmers, NGO) to keep the systems up and running, and their willingness to pay a small fee to use it. Despite the interest expressed by local users, in 2014 project partner Orange, who was responsible for the (cloud-based) voice platform Emerginov, pulled the plug and discontinued the whole project. The users were not pleased with the discontinuation of the ICT services.

It is difficult to estimate the costs of the development of the systems RadioMarché and Tabalé, because this was not financed by one single source. The project was not only an ICT4D project, but a field research experiment, involving students and researchers and producing project deliverables and scientific papers. The (minimum) estimated input to build the two systems would be: a project manager, four ICT developers, a requirement engineer, four radio journalists, two NGO staff members, a speech technologist, 19 local farmers. The estimated cost is about 40 person.months. In Chapter 8 this financial aspect will be further elaborated.

A SYSTEM APPROACH TO EVALUATION The case of RadioMarché shows that impact evaluation of a complex ICT4D project needs a system approach. In this case the voice-based market information system RadioMarché increased the sales of tree-products for farmers from nineteen villages in the Tominian region. The RadioMarché system helped the farmers to increase their access to local markets, through broadcasts on local radios, and increase sales of tree products. The improved sales led to improved household income for the farmers involved. This has a positive and reinforcing effect on the cultivation of trees on farmland. As such, it reinforces and supports regreening in Mali through more sales of tree products. It also has a positive effect

38 It was an EU-funded project, VOICES, in the FP-7 program.
39 The VOICES project ended in July 2013.

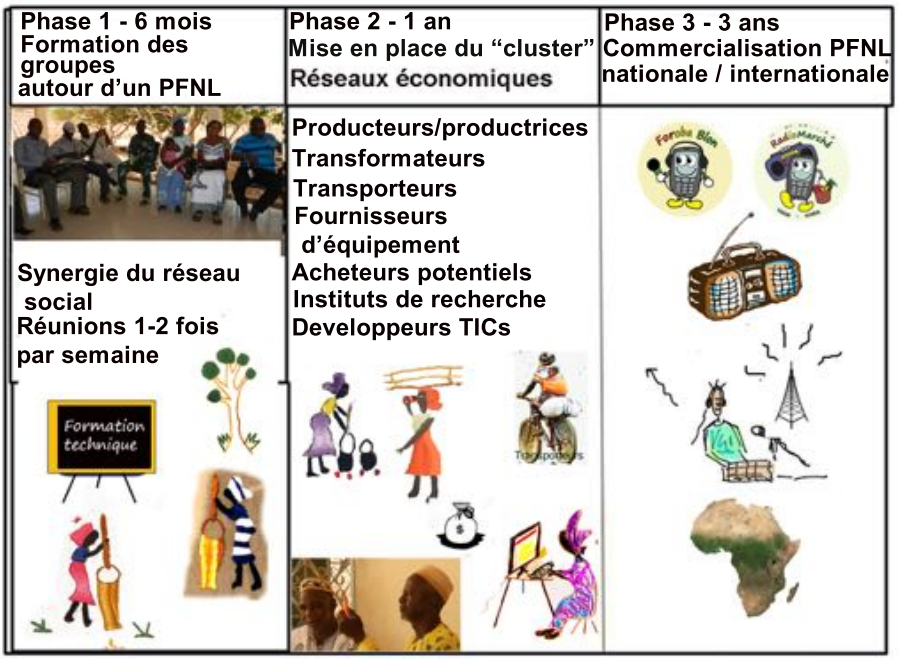

Figure 53: Plan by local users to scale-up the agro-forestry value chains, using ICT. Phase 1: formation of groups and training; phase 2: bringing together stakeholders; phase 3: commercialization of the forest products using RadioMarché and Tabalé. (*PFNL - produits forestiers non ligneux*) By Amadou Tangara and Anna Bon.

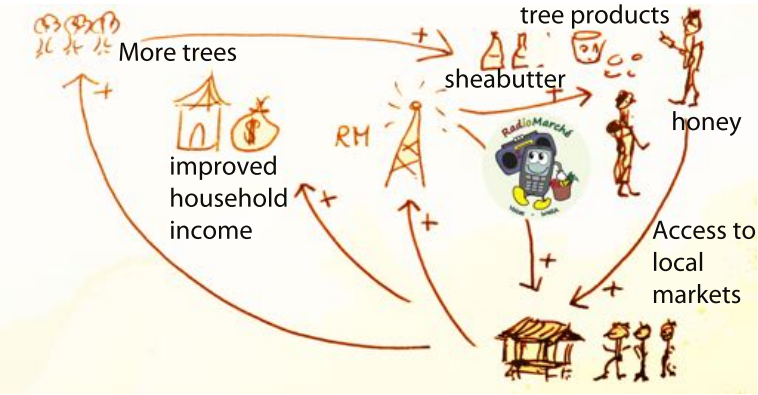

Figure 54: This causal loop scenario shows how the innovative technology RadioMarché is embedded and interacts with various variables in a complex context. This model represents a "theory of change", but one grounded on empirical field data and experience.

on food security, through improved household income for farmers. The complex interacting variables are visualized in a concept map in Figure 54, showing a number of local variables, and how RadioMarché interacts in this complex context. This concept map is also a representation of an alternative "theory of change", but one grounded in empirical data and extensive field research (in contrast to the linear, desk research based theory-of-change, often used in development projects [298]).

LOCAL PLANS TO SUPPORT EMERGING VALUE CHAINS Based on the experiences with RadioMarché, Amadou Tangara with feedback from farmers in the Mopti region, developed a 36 month scaling up plan for value chains of non-timber forest products (NTFP) in rural Mali. The technical plan was formulated by Tangara and reported and published as a W4RA working paper by the Network Institute[40].

The plan consists of three phases. The first phase (of six months) is to train groups of farmers during six months in the transformation of forest products, e.g. how to produce (home made) sheabutter, and filtered honey. Farmers will also receive training in financial management. The second phase (of one year) is spent organizing/improving the local value chain for the specific product, bringing together groups of farmers, producers, local transporters, potential customers, microfinance organizations, research institutes and ICT developers, to create the social environment for the value chains. The third phase (of up to three years) will be devoted to commercialization of the products across regions and to other countries. This requires ICT services, similar in setup and having mobile voice interface like the ones in RadioMarché and Tabalé. This plan, as designed by Amadou Tangara, is conceptually visualized as a diagram in Figure 53.

40 See: http://w4ra.org/wp-content/uploads/2014/08/Web-of-Voices-Working-paper_v0.11.pdf (accessed 31-07-2019)

7.7 SUMMARY

This chapter has shown that engineering, deploying and evaluating can be done in a non-interventionist, collaborative, adaptive, iterative way that accounts for the specific on-the-ground context. The case of RadioMarché is an example how real innovation works and how local users can influence the process and outcome of an ICT4D project. The pilot demonstrates the importance of extensive sociotechnical field research, of cultural aspects, of collaborating with end-users, of embedding an ICT system in the local context. The RadioMarché pilot also shows the emergent nature of outcomes and impact in a complex ICT4D project, that could not have been foreseen at the start of the project. The causal loop scenario in Figure 54 illustrates the RadioMarché project as an alternative, systemic "theory of change", grounded in field-based empirical data and experience.

Despite the promising results of RadioMarché, many problems still remain unsolved in ICT4D: problems related e.g. to infrastructure, language, illiteracy and many other issues. One major problem revealed by this pilot is the issue of sustainability of ICT4D systems and services. How can this issue be addressed and anticipated upon, at an early stage of ICT4D development? In the next chapter, the problem of sustainability in ICT4D will be discussed.

8

SUSTAINABILITY AND ICT4D

Sustainability is the achilles heel of ICT4D projects. Many projects do not survive after the period of donor funding. ICT4D still lacks good methods that help understand which factors contribute to sustainability or to the contrary. This chapter examines the key issue of sustainability of ICT solutions in development. It is obvious (although not often mentioned in ICT4D studies) that economic sustainability of a new ICT service depends on the value that it brings to all stakeholders involved. Based on this simple premise, the next question is to understand how value will be provided by an ICT service. We propose a methodology that allows assessment of sustainability upfront. This is done by making scenarios and evaluating various possible outcomes, already before deployment. To this end, a novel method is used, based on the e^{3}value *networked business modelling theory and methodology. We illustrate this with an example of a voice-based ICT service, deployed in rural Mali*[1]*. Our method supports the fourth Principle for Digital Development: Build for Sustainability*[2]*.*

8.1 THE BUSINESS MODELING DIMENSION IN ICT4D

As discussed in Chapter 1, the high rate of unsuccessful project outcomes of ICT4D is of general concern in international development. In previous chapters we have attributed this to approaches that ignore local operational goals and real-world context. Apparently, ICT4D projects lack the tools and methods to assess sustainability and feasibility of ICT4D projects before deployment, making deployments often a situation of "hit and miss". There are similarities here with the early days of the Web (in the 1990s). In those days many new ICT and Web services were set up, which soon proved not to be sustainable. This was due to the lack of a realistic business case, and lack of insight in the *value proposition* of a proposed ICT service [120].

As is the case with all innovations, long-term sustainability of a service is an ultimate measure of success. To achieve this, stakeholders (end-users and service providers) must obtain something of value from the service, otherwise the service will not survive. As we will show in this chapter, an understanding how this works, starts with the assessment of local users' needs and operational goals. Moreover, a proper assessment of business requirements is necessary to model and evaluate different scenarios, upfront. A methodology to do this is presented in this chapter.

1 Parts of this chapter have previously been published by Anna Bon, JAap Gordijn and Hans Akkermans (2017) [28].

2 See: https://digitalprinciples.org/, (accessed 31-07-2019)

8.2 SUSTAINABILITY AS A REQUIREMENT: A BUSINESS CASE IN RURAL MALI

A farmer e.g. in Tominian, Mali may be interested in a mobile voice-based messaging service that provides her with market information. However, she will only pay for the service, when it creates a real added value for her. A small entrepreneur such as a radio station, e.g. radio Moutian in Tominian, may be interested in participating in the future commercial voice-service delivery. However, the profitability of the service for the radio station is not obvious upfront. In order to help create ICT-service ecosystems in resource-low regions such as rural Mali, a sustainability-oriented approach in ICT4D must be taken, based on the idea of *value*, value exchange and value networks.

In general, ICT services based on network technologies are provided in networked constellations (see e.g.[216]), or as we call them "value webs", in which each enterprise brings in a specific core competency. All these competencies of the participating enterprises in the value web jointly satisfy a customer need, which could not have been satisfied by a single enterprise.

Likewise, innovative mobile/web services in Africa consist of networked constellations. These constellations may look different from the ones in high-tech e-commerce settings. The speed of transactions may be slower than in Internet-based e-commerce, especially due to absence of on-line payment services. They may involve paper-based transactions between "low-tech" actors such as farmers, village reporters, local organizations, rural radio stations etc. Still, as argued in this chapter, the concept of value web is valid in low-tech, constrained rural contexts. This will be illustrated by an example of a voice-based radio service, deployed in rural Mali.

We propose a methodology to assess financial sustainability of an ICT4D project upfront (ex ante) and/or after implementation (ex post). Here, it is important to note that – as we want to evaluate the feasibility and long-term sustainability of an ICT service – the entire value web must be evaluated. We therefore selected the e^3*value* methodology [119, 120]. This methodology has the advantage that it allows to make different future scenarios using different conditions, ex ante.

The novelty of our proposed method is in (i) assessing sustainability from multiple perspectives, i.e. for different stakeholders simultaneously, and (ii) the construction of multiple and alternative business scenarios.

8.3 A METHOD TO ASSESS SUSTAINABILITY

The e^3*value* methodology provides a conceptual modeling tool[3] for qualitative and quantitative assessment of feasibility and sustainability of a networked business idea. It is supported by a graphical language and software tool to assess the economic sustainability of innovative e-biz network projects. In this chapter we show how this methodology can be employed to assess sustainability of ICT4D projects.

3 See: http://e3value.com (accessed 31-07-2019)

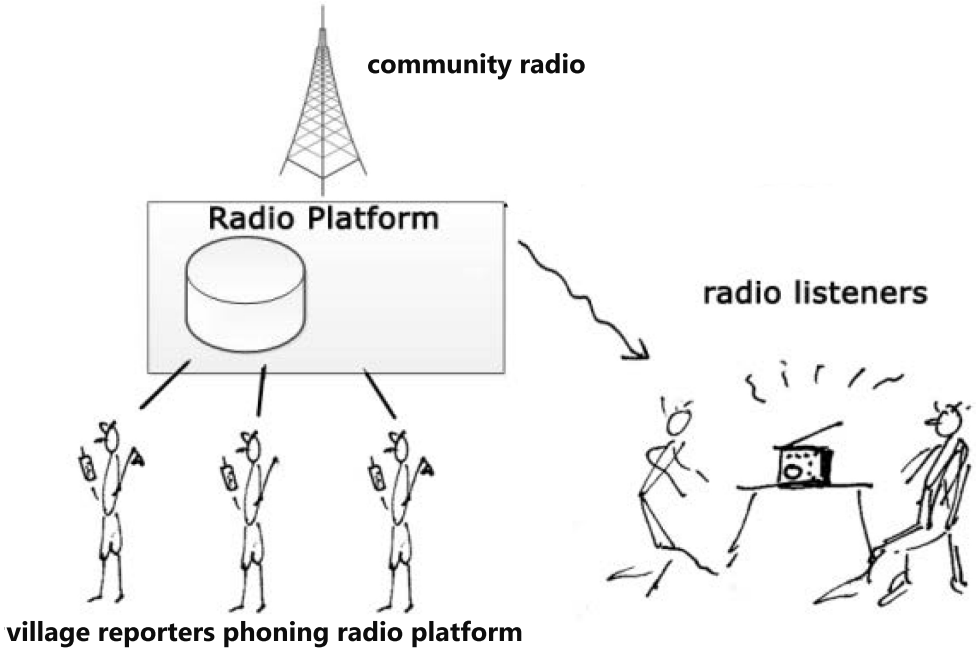

Figure 55: Sketch of the radio platform for people who are out of reach of computers and the Internet, and want to leave a message for broadcasting on the radio.

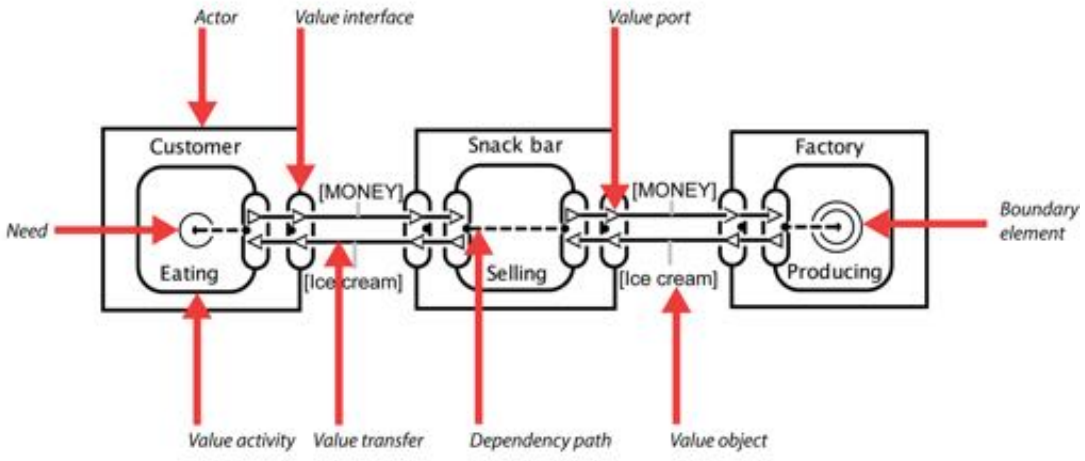

Figure 56: An educational e^3value model, adapted after J. Gordijn & H. Akkermans 2001 "e3-value: Design and evaluation of e-business models" *IEEE Intelligent Systems*, 16(4):11-17. Copyright Gordijn & Akkermans [119].

Figure ?? shows a simple illustrative example of the e^3value model, for a customer buying an ice cream from a snack bar. The snack bar, in turn, obtains the ice cream from the ice cream factory and pays for it. The example explains the various concepts underlying the e^3value method. (The following text is an excerpt from [119, 120].

The simple e^3value model in Figure ?? shows entities exchanging value objects. In this case the entities are single actors – e.g. a customer, an ice cream factory, a business – exchanging value objects in a value network. The value objects (e.g. an ice cream, money) represent economic value for the actors. The actors exchange (provide or require) value objects via value ports. Value ports are grouped into value interfaces. These value interfaces model the economic reciprocity, which exists in every business transaction. Evidently, an actor provides a value object only, if he or she gets something in return, of equal or higher value.

Entities, in e^3value , can be single actors or entire market segments. Market segments are represented graphically in the e^3value ontology as a stack of actors. (For the sake of simplicity, the market segment is not shown in the example of Figure ??). In a market segment every actor has the same economic utility function for the given model.

In Figure ?? a customer and a snack bar exchange an ice cream for money. This occurs through a value transfer. This models the actual transfer of the value object (the ownership of the ice cream is transferred from the snack bar to the customer). Given the reciprocity principle, when an ice cream is transferred, money is transferred in the opposite direction.

A customer need is central in the business process: in this very simple case, the customer wants to have an ice cream. To satisfy this need, an exchange of value objects takes place via an interface, in casu ice cream against money. This is modelled by connecting the value interfaces by dependency paths. It becomes clear that the snack bar obtains the value object (ice cream) from the ice cream factory. A boundary element at the ice cream factory indicates where this value transfer actually ends (which demarcates the scope of the model).

8.3.1 *Sustainability assessment in ICT4D*

The e^3value model makes it possible to calculate a net cash flow for each actor in the value network, and can therefore serve as an indicator for feasibility of the value network as a whole. We therefore will analyze the socio-economic network *as a whole*. Not just individual actors, as usually done in other business modeling methods. Below is explained in five steps how one can assess the sustainability of innovative ICT services in rural African contexts. This is an iterative, collaborative approach which starts during needs assessment, see Chapter 5.

STEP 1: CONCISELY STATE THE ICT4D IDEA As described during the use case and requirements analysis, an assessment of stakeholders, their relationships and operational goals is made. The use case is described in terms of business and operational goals and objectives. This ensures that the system is embedded into the local ecosystem. The important point to stress here is that it is essential to analyze the socio-economic network as a whole – not just individual actors, as usually done.

STEP 2: REPRESENT THE ICT4D IDEA AS AN e^3value DIAGRAM The concisely stated ICT4D idea and the e^3value approach are used to construct a graphical representation of the ICT4D idea. Typically, workshops with the stakeholders involved in the ICT4D idea are necessary to construct an e^3value diagram that is agreed upon by all these stakeholders, and that represents the ICT4D idea adequately.

STEP 3: ASSESS ECONOMIC SUSTAINABILITY FROM A STRUCTURAL POINT OF VIEW From the e^3value model we can assess the economic sustainability of ICT4D in a qualitative manner. Depending on the actual case, observations can be done without doing calculations at all. As a general rule, each actor in the network should have some benefit, otherwise there is no sustainability.

STEP 4: ASSESS ECONOMIC SUSTAINABILITY FROM A QUANTITATIVE POINT OF VIEW This step involves quantification of the e^3value model to assess economic sustainability of the ICT4D project. There are various diagram elements that require quantification. First, the number of customer needs per timeframe (e.g. one year) must be

stated. Second, in case market segments are used (e.g. to model a number of customers), the number of actors which are part of that market segment must be given. Using the estimated figures, the *e*^{3}*value* software is used to conduct a quantitative analysis of the *e*^{3}*value* model. If the quantification is done correctly, the *e*^{3}*value* software can generate a net value flow sheet for each actor in the network. The flow represents a monetary unit for each value transaction. Clearly, if this flow is a negative value (on the long term), the ICT4D project cannot be considered sustainable. In order for the ICT4D idea to be sustainable, all the actors in the diagram should have a positive net cash flow.

If the *e*^{3}*value* methodology is used to design a new ICT4D case, its quantification is always an estimate. If the assessment is done while the ICT4D service is already up-and-running, the quantification should be based on actual numbers of the case. Before quantification starts, it is necessary to agree upon the timeframe the *e*^{3}*value* diagram spans. Typically, a timeframe of one year is used, however, it is equally well possible that the timeframe is a month, week, or day.

STEP 5: IMPROVE THE ICT4D IDEA BY REVISING THE *e*^{3}*value* MODEL The proposed sustainability analysis is done iteratively. It is normal that a first version of the *e*^{3}*value* model may not produce a final result. In order to improve the model, the quantification can be iteratively improved/optimized. The generated net value flow sheets indicate which actors experience problems. We can modify values and recalculate until we understand under which conditions a positive value flow for all actors will occur. *e*^{3}*value* can also be used to build alternative future scenarios for ICT services, as will be shown in the following case from an ICT service in rural Mali.

8.4 CASE: DEVELOPING AN ICT SERVICE IN RURAL MALI

This section describes the case of Foroba Blon, an ICT4D system designed and built to support citizen journalism, rural radios and farmers in rural Mali. The Foroba Blon system was jointly developed by the W4RA team, SBC4D and Malian NGO Sahel Eco in collaboration with five rural radios in Mali. The project was awarded the IPI (International Press Institute) Innovation Prize 2011 and received a grant of 250.000 US dollar[4]. A logo for Foroba Blon was designed by Victor de Boer, see Figure 59.

To develop the Foroba Blon service many co-creation workshops and focus group discussions were organized in the period 2011-2012 in Bamako, Ségou, Tominian, San in Mali. These collaborative workshops were aimed at better understanding the local context, at reducing the cultural distance between all stakeholders, and at elicitation of technical and business requirements. User evaluation of the technical architecture and business models was also done iteratively during face to face meetings between developers and users. The Foroba Blon service was built at the request of three Malian

4 See https://tinyurl.com/forobablon-wins-IPI-contest, (accessed 31-07-2019)

Figure 57: The office of radio Moutian in Tominian, Mali. Photo: Bruno van Moerkerken.

radio stations (cf. Figure 57), to facilitate an existing (paper-based) workflow. The name of the system/service, Foroba Blon, (some people write " Foroba Blo") in Bambara language refers to a large space, where everyone has the right to speak in front of the village chief; the truth must be told here, but only respectfully, without insulting anyone. The name was given to the service by the radio journalist from Radio ORTM Ségou, Fousseyni Diarra.

The Foroba Blon ICT service consists of a voice-based micro-blogging service. The key idea is as follows. People from rural villages (without having an Internet connection), send a voice message by (simple, GSM) mobile phone to a local radio in their region, because they want to do an announcement on the radio (for example a wedding, a funeral or reporting a missing cow). The radio journalist accesses the incoming (spoken) messages via a web or (mobile/voice) interface on his/her local computer. The radio station charges a fee to the customer/villager, for broadcasting the message.

In the sustainable study on the Foroba Blon system three different scenarios of a voice and radio-based ICT-services are shown, developed and deployed in rural Africa, in close collaboration with the local end-users. During the workshops, different actors were identified, who would make up the value web for ICT-service delivery and consumption. The following information was collected during various focus group discussions with radio journalists, local NGO staff members and farmers. (The full process according to the stepwise approach for the first scenario is described in the next sections. For the second and third scenarios only the qualitative results of the business analysis are presented.)

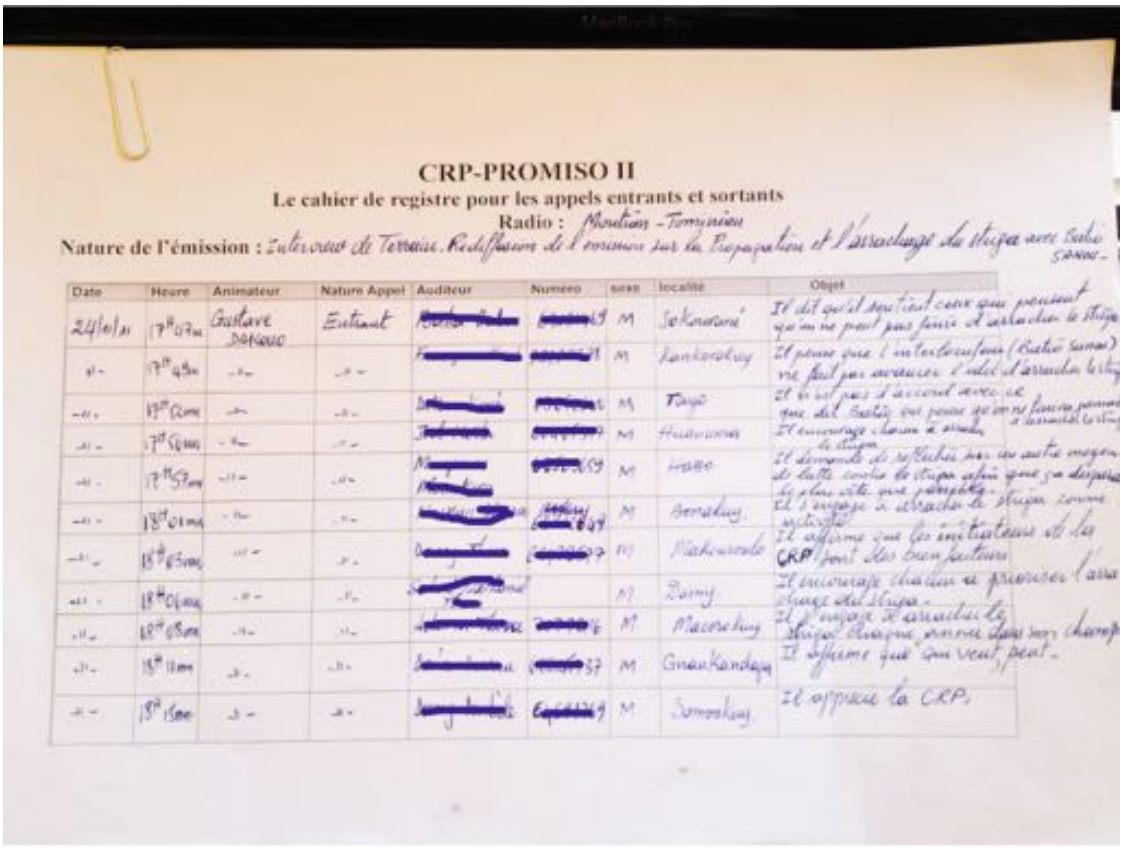

Figure 58: At radio Moutian the incoming messages are registered by hand in a caller log, November 2011. Photo Bruno van Moerkerken.

8.4.1 *Radios are potential service providers*

As discussed in Chapter 5, rural radios are important local information providers and hubs in rural Africa, in the absence of other mass media (Figure 57).

The same Malian community radios were involved in the Foroba Blon research project as in the RadioMarché project: (i) Radio ORTM Ségou, a state owned radio that has computers and a fixed Internet connection (DSL). Radio ORTM Ségou broadcasts programs in French and Bambara, the most widely spoken language in Mali; (ii) Radio Moutian, in the village Tominian, an independent radio, that generates revenues from selling airtime for announcements and receiving some private gifts from third parties. Radio Moutian has a computer but no Internet connectivity. Programs are mainly broadcast in Bomu, a local language in the Tominian region; (iii) Radio Seno in Bankass. This is an independent radio, with only analogue equipment: no computers, no Internet connection. Still, this radio has many listeners (80,000) in the area around Bankass, in the south-east of Mali. The language spoken here is Dogon. The activities

Figure 59: Members of the Foroba Blon (or "Foroba Blo") team at Radio Moutian, Tominian, Mali, November 2012. (The Foroba Blon logo is visible on their T-shirts.) Photo: Anna Bon.

of the three above mentioned radio stations are related to different types of customers and business contacts.

8.4.2 *The village reporters*

Journalists or trusted village reporters work for the radio. They provide them with local news from the villages or interviews with village people, on a regular base. In the initial (low-tech) situation, all incoming phone calls are attended by a radio staff member and annotated in tabular form on paper (see Figure 58).

Another service provided by village reporters is the provision of mobile phone access for villagers without phone. Often these are non-commercial radio listeners who want to send a spoken announcement to the radio, but do not own a mobile phone. These village reporters act as service providers between the villager and the radio. Apart from phone access, they arrange the payment for the broadcast between the villager and the radio. They receive a fee for this service.

8.4.3 *Potential customers*

The proposed service has three types of potential customers (actors as a market segment).

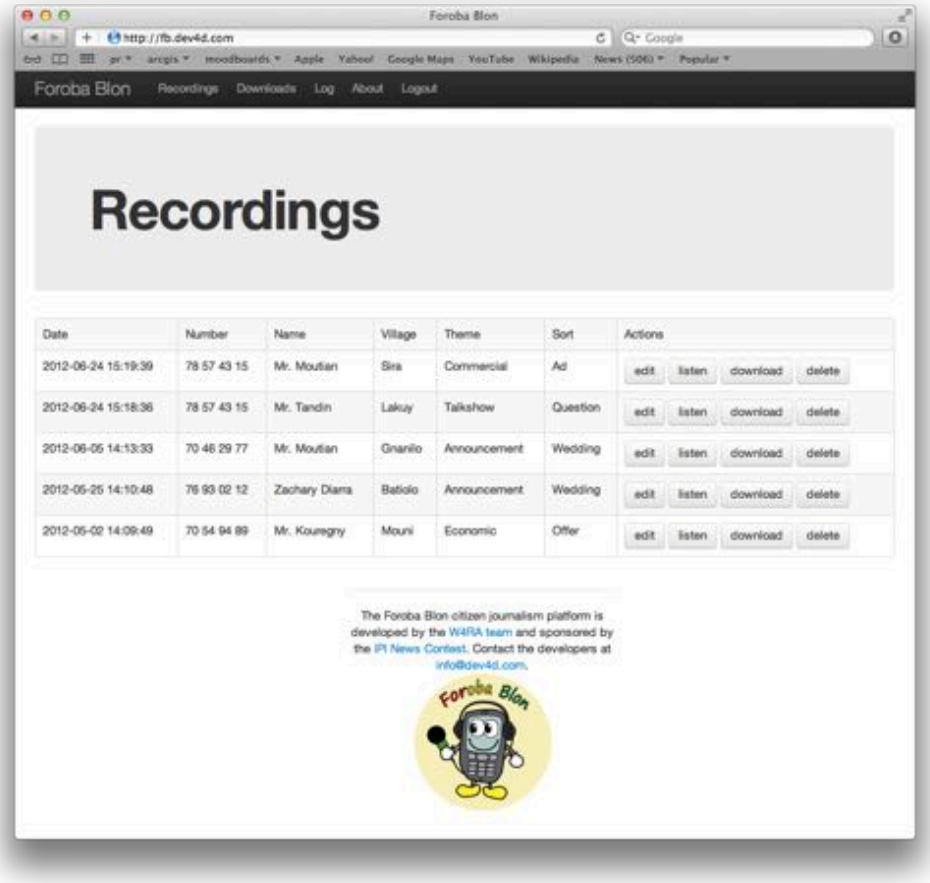

Figure 60: Screenshot of web interface for Foroba Blon, for managing audio content. This first version of the system was developed together with Stéphane Boyera; the logo is by Victor de Boer.

1. Non-commercial radio listeners living in the surrounding rural communities buy a few minutes of airtime and pay a broadcast fee per minute airtime. Their average income is usually between 1 and 2 US$ a day. The information is usually brought to the radio on paper, or communicated via phone and subsequently written down on paper by the radio staff. These announcements can be e.g. about weddings, funerals or other messages to the public.

2. Non-governmental organizations (NGOs) buy airtime to broadcast public announcements about informative and educational topics, such as agriculture and public health information. They pay the radio a fixed monthly subscription fee for recurring broadcasts.

Figure 61: Journalist Bakary Dembelé at work at Radio Moutian in Tominian, Mali. Photo: Bruno van Moerkerken.

3. Commercial services broadcast advertisements on the radio. These were not taken into consideration in the model, but are a potential future source of income for the radios. The fees charged for commercials are 150 percent of the fee for private announcements[5].

8.4.4 *The technical architecture*

The proposed radio service which we coined Foroba Blon (FB) runs on a platform consisting of a data store. This is where recorded voice messages and related meta-information are stored, as shown in Figure 55. The Foroba Blon service will replace the existing legacy system, which is a hand-written, paper-based caller log, see Figure 58. The interface to the service is either mobile (GSM) or web-based. Calls are answered by the system with a pre-recorded welcome message in a local Malian voice inviting the user to leave a message.

The incoming, recorded voice messages are stored as audio files in the data store, with meta-information: date and time of the call, length of phone call in seconds, phone number of the caller. Messages from trusted users are linked to owner, his/her address, and his/her preferred language. For all users of the system, confidentiality and anonymity are ensured, according to broadcast policies used by the radio stations in Mali.

5 Source: Personal information by Adama Tessougué, Radio Sikidolo, Mali, May 2016.

For web users – the radio journalists who have Internet access – the service provides a web-based interface, enabling them to manage the data in the data store. It provides a file list where they can access, listen, broadcast, delete files, and add/update/delete meta-information, see Figure 60.

The physical radio platform can be hosted either locally, on a stand-alone computer, even without an Internet connection, or *in the cloud*. It includes a voice-server, i.e. an open source web server and a local voice browser that handles the voice interaction (see e.g. Figure 50).

8.4.5 *Organizing the radio content*

The next challenge is how to manage the spoken content of un-resourced languages such as Bomu, Bambara and Dogon. Since up to present no interactive voice response (IVR) systems exist for these languages, the voice-based content cannot be indexed by conventional search engines. Therefore collecting as much meta-information as possible is essential. Very simple ways of indexing the messages are based on owner (known through phone number), automatic language recognition, time slot, (e.g. *all messages collected on January 13 between 10 and 11 a.m. are related to the radio program on harvesting shea nuts)*. The radio journalist can manually enter meta-information such as keywords, village region, language, name or any other attribute to an audio file using her radio-web interface.

8.5 EVALUATION OF DIFFERENT POSSIBLE BUSINESS MODELS

The first release of the voice-based micro-blogging system, Foroba Blon, based on local business idea and requirements expressed by the radio journalists, was tested and taken into production by Radio Sikidolo in Konobougou and radio Moutian in Tominian, Mali. (The technical architecture of the Foroba Blon platform has been previously published [131, 23]). This version of the FB system was engineered by Stéphane Boyera.

We received extensive feedback from the radio journalists about the assets and the problems they experienced while using the Foroba Blon system. This feedback was used to construct value models, based on real and estimated costs, and used to predict feasibility. Accordingly, scenarios for potential services were designed and analyzed for Foroba Blon. The analysis using the e^3*value* methodology yielded three business models that can be feasible and sustainable; they are associated, however, with different roles and network configurations of involved actors. Each model also has different implications for the technical ICT requirements. Scenario I was based on a paper-based legacy system that the radio stations are already using. Scenarios II and III were new in 2012, and not based on a legacy system. They were initially only thought experiments, used to evaluate if alternative services for Foroba Blon would eventually be sustainable.

Scenario I is about a village reporter who owns a mobile phone and sends messages from people who do not own a mobile phone to the Foroba Blon system. For this service, the village reporter obtains a small fee.

Scenario II supposes there will be commercial parties such as a local business, who want to broadcast announcements. These commercial users pay a fee for every broadcast.

Scenario III is about a news provider who wants to obtain news items from the local region. The news provider can be a newspaper or a television station who wants to have content (the news items) to broadcast. For receiving local news, the news provider pays a fee. This last scenario became reality in 2012/2013 and showed the success of the idea of the Foroba Blon service in a totally different context.

8.5.1 *Scenario I: village-reporter based business model*

STEP 1: CONCISELY STATE THE ICT4D IDEA. The radio stations in rural Mali want to have a message system for citizen journalism, accessible through phone. In brief, such a system should allow citizen journalists to deliver voice messages to the radio station via a voice response system. The radio station should be able to retrieve the messages and broadcast the messages. The messages are short news reports from villages.

Before the deployment of the Foroba Blon platform, the rural radios already received voice messages for broadcasting, but these were usually written on paper. The village reporters brought these written messages to the radio station. The messages were broadcast as spoken messages by the journalist. Foroba Blon has improved the workflow by allowing customers (or village reporters) to phone in and record the message that they want to broadcast. The radio journalist can access the voice messages at a later time. The message is stored as an audio files. The radio journalist can select from a list of messages, optionally add meta-information and manage the list of received messages and broadcast when needed (as a web-based voice-mailbox).

STEP 2: REPRESENT THE ICT4D IDEA AS AN e^3value DIAGRAM. Figure 62 presents the e^3value model for the FB platform. There are six actors involved. The actors are customer (or sender), village reporter, radio station, telco, FB service provider and listener.

The customer is a person living in a remote village in Mali (e.g. Konobogou). The customer usually does not own a mobile phone. This person has a need (annotated #1) to announce a message to other people in the region. For instance, he wants to broadcast a message on the radio, because he is missing one of his cows. By reporting this lost animal on the local community radio, the message will be reached by 80.000 people, the listeners base of the radio station Sikidolo, in Konobougou. The customer pays for broadcasting the announcement on the radio.

Table 3: Prices of products and services.

Value object	*Value* (fCFA)
Announcement service (customer)	fCFA 1.000 per announcement
Announcement service (reporter)	fCFA 750 per announcement
Phone call	fCFA 100 per announcement
FB service	fCFA 200.000

The village reporter is a person in the village who owns a mobile phone. On behalf of the customer, he makes the phone call to do the announcement, e.g. concerning the lost cow, or allows the customer to do the announcement. For doing so, the customer pays a fee to the reporter. The AND-fork annotated #2 represents that the village reporter has to transfer economic value objects with two actors, namely the radio station and the telco. For each announcement broadcast by the radio station, the village reporter pays the radio station an amount of money. Also, the village reporter should pay the telco a fee for the telephone connection. This is just the normal fee to be paid to a telecom operator for a voice call.

At a certain point in time the radio station broadcasts the announcement to the listeners of the radio station. Explosion element annotated with #3 indicates that one received announcement by the radio station is broadcast to 80,000 listeners. A listener receives announcements. In general, announcements are considered as valuable to the listener because they reflect interesting content. In return for the received announcements, they give the radio station audience. As a radio station's primary goal is to serve an audience, this is of value to the radio station. Optionally, the radio station can use the audience to attract other sources of revenue, e.g. advertisements (not shown in the model).

Finally, the radio station obtains the voice platform service (FB) from the FB service provider and pays for this service, including regular maintenance. As this is a monthly service, the radio station pays only once per month, therefore there is one need per month for the platform.

STEP 3: ASSESS ECONOMIC SUSTAINABILITY FROM A QUALITATIVE, STRUCTURAL POINT OF VIEW. There are a number of observations that can be done by considering just the graphical model. The first observation does not consider something that is in the model, but what is actually missing in the model.

- *Observation 1:* phone lines, with corresponding subscription fees are not part of the model.

Table 4: Number of customer needs.

Customer need	*Count /month*
announcement (per customer per month)	1
FB platform	1

- *Explanation:* the proposed platform supposes that radio stations have their own infrastructure for handling telephone calls. The platform solves this by a GSM telephony device, which is connected to the Foroba Blon platform. The GSM device uses a pre-paid phone card, so there are no monthly subscription fees (only a one-time investment in the pre-paid card). Therefore, monthly subscription fees are not part of the model. A possible drawback is that the current platform only supports one GSM device per platform instance. This is fine for a service start up, but once the service is popular, customers may experience that the phone is occupied if they want to make an announcement. This may hinder further growth of the service.

- *Recommendation:* there are a couple of ways how to deal with a limited number of phone lines. First, the platform instances of the radio stations, each equipped with a GSM device, may use the devices of other platform instances if they are not occupied. However, this requires that radio stations exchange received messages with each other, which imposes telephone connection costs for the radio stations. Second, the platform may be hosted at a (telecom) provider, along with a number of land telephone lines. This however would result in expenses for hosting, as well as for telephone lines (subscription fees), and both are expensive in Mali.

- *Observation 2:* there is a one-to-one relationship between the radio station and the FB service provider.

- *Explanation:* as can be seen from the e^3*value* diagram, the FB service provider has only one customer, namely the radio station. The pricing of the FB service provider has been chosen in such a way that the provider at least has a positive cash flow. However, the total revenue is not sufficient for the FB service provider to make a living.

- *Recommendation:* the FB service provider needs more income. This can be achieved by attracting multiple local radio stations, operating in different geographical regions. On the short term, additional funding for the FB service provider can be arranged by donor funding. Such funding can be used to develop and improve the FB platform. On the long term however, the FB platform should be provisioned by multiple radio stations.

Table 5: Number of actors in a market segment.

Actor	*Count*
Customer	2.550
Village reporter	85

STEP 4: ASSESS ECONOMIC SUSTAINABILITY FROM A QUANTITATIVE POINT OF VIEW. In this step we detail the constructs numerically. We make reasonable estimates, as realistic as possible. The data for this model are provided to us by Adama Tessougué from Radio Sikidolo and Amadou Tangara[6].

1. Quantification of products and services. The customer pays for broadcasting an announcement on the radio and access to the FB platform fCFA 1.000. The alternative would be to travel to the radio station to leave the message personally. The travel to reach the radio station would cost him on average 4.000 fCFA. As this is not a viable alternative, we can consider it a sound motivation to use the FB service.

   The radio broadcasts the message and receives a payment for each broadcast announcement from the village reporter. The village reporter pays the radio station for each announcement fCFA 750.

   Also, the village reporter should pay the Telco for the phone call. We assume the average phone call costs fCFA 100.

   The radio station pays for the Foroba Blon service fCFA 200.000 per month.

2. Quantification of the number of actors. Table 5 shows the number of customers and the number of village reporters. We assume 2.550 customers for the total of participating villages. Also, there are 85 village reporters.

3. Quantification of the customer needs. There is, on average, one announcement per customer per month. On a daily basis, the radio station collects the submitted announcements, therefore there are on average 30 needs per month to collect such announcements. Finally, since the subscription on the Foroba Blon platform is on monthly basis, there is one need per month. This is summarized in Table 4.

Similar to the first case, we use the e^3*value* toolset to generate net value flow sheets, the result is in Table 6. Again, we summarize a few observations based on the net value flow calculations.

- *Observation 3:* the telco and radio station are the winners.

6 Amadou Tangara is currently country manager in Mali for Tree Aid in Bamako.

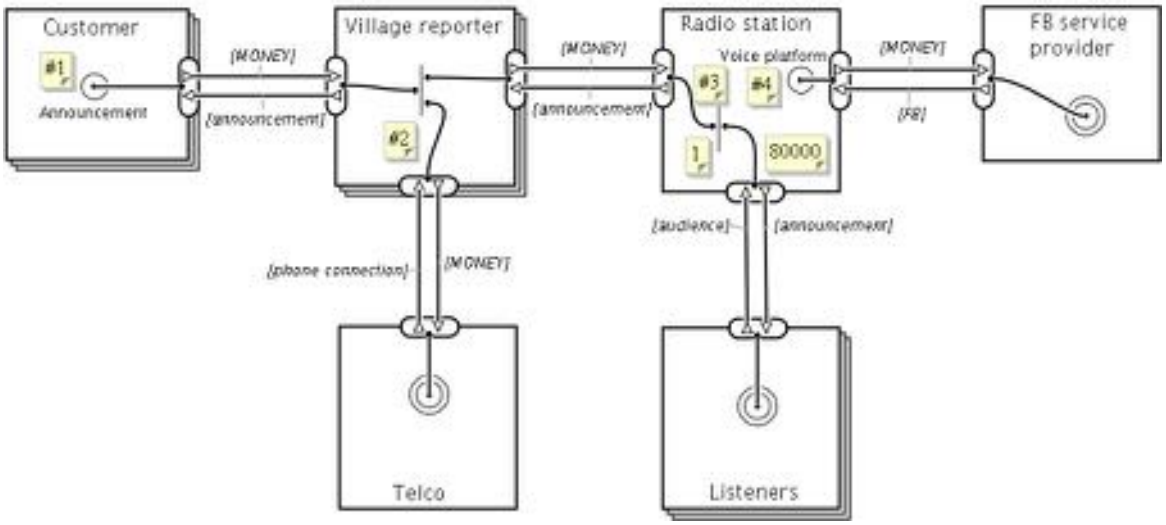

Figure 62: Scenario I: village reporter based business model. By Anna Bon and Jaap Gordijn.

Table 6: Sustainability analysis using the e^3value model.

Actor	*Revenue per actor* (fCFA)
Village reporter	fCFA 4.500
FB service provider	fCFA 200.000
Telco	fCFA 255.000
Radio station	fCFA 1.712.500
Customer	fCFA - 1.000
Listener	n.a.

- *Explanation:* considering all actors in Table 6, the radio station and the telco are the parties who earn most of the money in the system. Both the radio station and telco are actors of which there is only one in the model. Naturally, these parties collect most of the money.
- *Recommendation:* the model may benefit from competition. For the radio station, this would imply addition of radio stations that operate in the same geographical region. This may lead to price competition between those radio stations. The same holds for the telecommunication companies; the world-wide model of mobile telephony allows competition between operators in the same geographical region.
- *Observation 4:* the village reporter earns a modest amount of money.
- *Explanation:* the village reporter only earns fCFA 4.500 per month, which is, compared to the price to be paid for a single announcement by the customer, not much.
- *Recommendation:* the revenue for the village reporter is low, but the service provided (lending the phone for a minute) is rather shallow too. Therefore, the revenue sounds not unreasonable and therefore acceptable. The low revenue is caused by the relative high number of village reporters. There is competition here, and the total amount of money related to the submission of announcements must be divided over a large number of village reporters.

STEP 5: IMPROVE THE ICT4D IDEA AND e^3value DIAGRAM. The model as proposed is useful for a field test. It has to be taken into account that the FB service provider cannot really make a living by having just one radio station as a customer. This may be solved with donor funding. In the longer run, the value model should evolve:

1. More radio stations should participate. From a modelling perspective, this would imply that the radio station in the current model becomes a market segment (multiple actors) rather than one actor.
2. Having more than one operator available would possibly lower the fees. Also here, the mobile operator would – from a modelling perspective – change into a market segment.
3. The current technical solution, namely one mobile phone per radio station, does not really scale well, once the service gets popular. There is then an increased chance that customers will not be able to deliver their announcement. There are various ways to solve this. A first option would be to use (multiple) land lines per radio station. This requires that the radio station takes a subscription at those

lines, supplied by a telecom operator. This would change the value model. A second option is that the Foroba Blon platform is capable to forward phone calls to other platform instances. In other words, if a customer tries to connect to a particular radio station and that station is occupied, that customer is re-routed to another, not occupied radio station. Also, this option results in a change in the value model. First, radio stations may charge each other for this service; second, radio stations need to obtain messages delivered at other radio stations using some communication mechanism for which costs are involved.

IMPLICATIONS FOR ICT REQUIREMENTS The village reporter-based business model was designed and built following existing practice and workflow at Radio Sikidolo, who came up with the initial idea. The first-cycle deployment was done and radio journalist Adama Tessougué tested the system with a number of village reporters. He was pleased with the system and came up with some technical adjustments and new requirements, which affect the technical design and the business model.

- A notification message must be sent as an SMS text-message to the radio, once a new voice-message has been issued. Since Radio Sikidolo had no Internet at the time of first deployment (2012), he had to phone in to the Foroba Blon system. When testing the system, the radio spent several phone calls to access the Foroba Blon system, while no messages had been issued. Since the cost of a phone call in Mali is relatively expensive, this was an important cost-driven ICT requirement.
- A mobile payment system, so that the broadcast service can be paid to the radio, was one of the requirements to avoid cumbersome cash transactions between the radio and the village reporter. Moreover, paying in advance discourages people to phone in to the Foroba Blon service and leave fake messages. During the first cycle, mobile payment systems were not available for mobile operators in Mali (the main ones here are Orange and Malitel). In 2013 mobile operator Orange launched Orange Money as a mobile payment system in Mali. An application programming interface provided by the local mobile operators (Orange, Malitel) allows further development of modules for mobile payment (based on mobile airtime).

8.5.2 *Scenario II: radio-based advertisement business model*

The second value model for Foroba Blon has a different type of customer, for example a commercial business that wants to advertise a product or service, an NGO or governmental department that wants to send information to a broad audience, e.g. on health, agriculture, education. In the value model shown in Figure 63, the customer wants to broadcast a message (such as an ad) to a large audience.

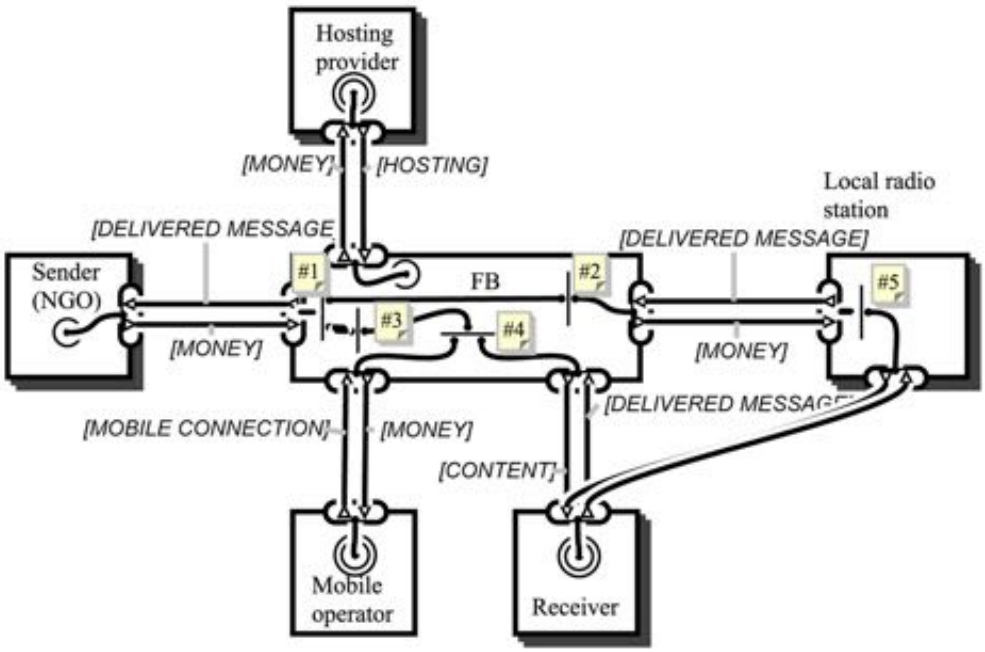

Figure 63: Scenario II: the sender pays directly to the provider of the Foroba Blon service. By Anna Bon and Jaap Gordijn.

The sender obtains from the Foroba Blon system a delivered message and pays a fee in return. Note that in this model, Foroba Blon is the commercial entity the sender deals with, in contrast to the village reporter-based business model where the radio station is the party the sender deals with. Then the AND fork annotated with #1 indicates that two things happen: (1) the message is broadcast via radio stations, and (2) the message is sent via mobile phones to receivers.

In case the message is sent via radio stations, the upper dependency path is followed (inside Foroba Blon). The explosion element marked #2 indicates that one message can be broadcast via multiple radio stations, thus reaching a larger audience. The local radio station delivers the message to its listeners (the receivers) and gets paid for that by Foroba Blon.

The message is sent via mobile phone connections to subscribers. This is represented by the lower dependency path inside Foroba Blon. The explosion element marked as #3 shows that one message is sent to multiple receivers. The AND fork annotated with #4 indicates that for the delivery of a message to a receiver, there are value transfers necessary for the mobile connection (with a mobile operator) and for the message delivered to the receiver.

The receiver provides the service of a delivered message to Foroba Blon (or the radio station). Similarly, Foroba Blon offers a delivered message to the sender. As message

delivery is of value to the sender, the related transfer points towards the sender. It is supposed here that the content of the message is of value somehow to the receiver. Consequently, there is a value transfer from Foroba Blon and the local radio station to the receiver representing the economic value of the content of a message.

IMPLICATIONS FOR ICT REQUIREMENTS Based on feedback and evaluation of the models, the technical architecture is refined and re-adjusted. New requirements that came up after the business model was designed were:

- Since the sender in this case has an Internet connection, a new requirement is a web interface where the sender can enter the message to be broadcast;
- A new requirement by the NGO was to add the possibility to stream the message to a number of phone recipients, instead of sending it to the radio for regional broadcast; with this addition, the message can be optionally sent to a limited number of recipients, if the sender wants to reach a limited number of known contacts (e.g. to invite 50 participants for a meeting or event).

8.5.3 *Scenario III: citizen journalism-based business model*

This business model supports citizen journalism in e.g. rural Mali. This model shows an information pull, in which local reports by village reporters and local citizen journalists are requested by the customer, which is e.g. a large media company (the news provider).

The news provider (e.g. Al Jazeera, CNN, ORTM, BBC, Wereld Omroep) needs news items (context) for their programs. Part of this content is obtained from regional reporters in the field. This is especially interesting regarding the unstable political situation in northern Mali, where incidents may take place, reported by eye-witnesses and village reporters, or during presidential elections, e.g. in Ghana or Kenya, or during e.g. ebola-outbreaks in the country. News providers pay a fee per news item to Foroba Blon. The FB service obtains voice-based news messages from local radio stations. Local radio stations are paid a fee per delivered news item. In order to facilitate delivery of news items by local reporters via mobile phones, the FB service provider has a contract with a mobile operator. The value model in Figure 64 shows that the FB service provider pays per news item a mobile operator fee for a telephone connection. Note that the FB service provider pays for the phone connection and not the reporter. In reality, this is implemented as a toll-free number that reporters can use for free, while FB pays for this toll-free number.

IMPLICATIONS FOR ICT REQUIREMENTS Based on feedback and evaluation of the models, the technical architecture is refined and re-adjusted.

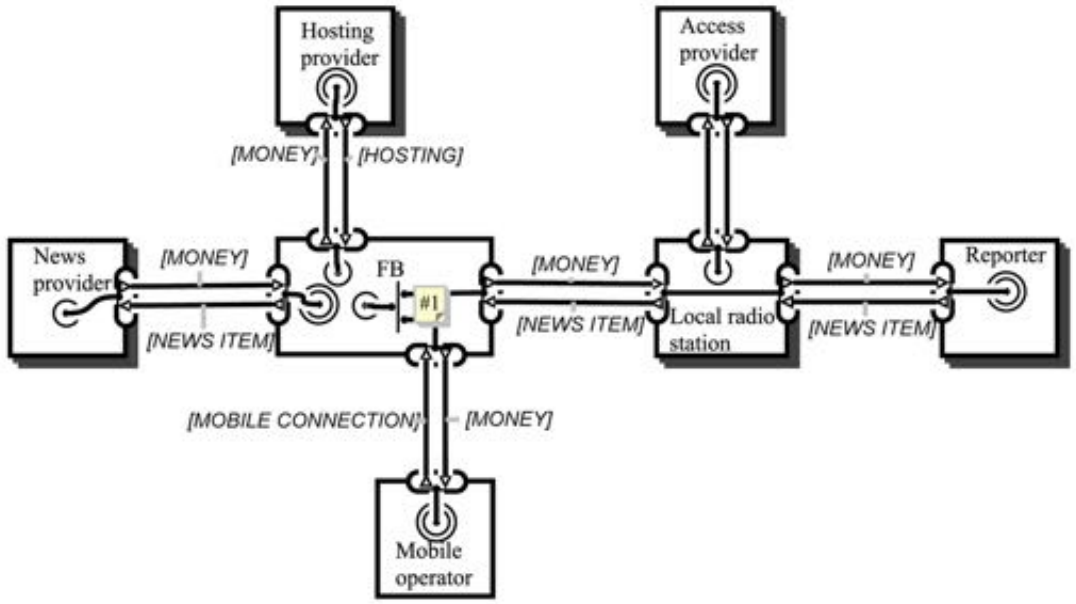

Figure 64: Scenario III: the news provider pays for obtaining regional news items. By Anna Bon and Jaap Gordijn.

The technical design of this business model is similar to Foroba Blon model I, only the business case is different, because different values are transferred. The village reporter now sells his voice report to the news provider, instead of buying broadcast airtime from the radio. This requires the following additional technical requirements:

- A payment module must be built into the web interface of the customer, in which the radio and the individual reporters are remunerated for each relevant report they enter into the system;
- The radio station, who operates as the intermediary between the village reporter and the customer, has an Internet connection to do the management of the content and the payment to the village reporter;
- A toll-free number is provided by the telecom operator for the village reporter, who no longer pays for entering a message. He receives a payment for each spoken news item entered into Foroba Blon and accepted by the customer.

Local radio stations in turn obtain news items from freelance reporters. In turn, these reporters are paid a fee per news item. The radio station also organizes and enriches each news item with some meta-data, such that it can easily be accessed online by the customer.

8.5.4 *Discussion of the development process of the business models*

The first scenario we designed and built was based on a business idea by local radios. The service replaces an existing (legacy) work flow, which was an existing, cost-effective, legacy broadcasting service from the radio to the rural community. The customer and the radio station experienced improved efficiency once the Foroba Blon service was operational. Radio journalist Adama Tessougué tested the Foroba Blon system with a number of village reporters in Konobougou and surrounding villages.

The second and third value model scenarios are examples of new services that were adaptations of the initial service. Value models II and III, described above, did not exist previous to the Foroba Blon deployment. These models represent a local innovation – or rather a local reinvention – as a consequence of the introduction of an innovative technology in this local rural (constrained) environment.

In models II and III the village reporter (or farmer, or rural community member) is no longer the customer or sender in the value model, but a service provider or a targeted market segment. The farmers provide the listeners base, for the customer (NGO or advertiser, etc.) who wants to send information or advertisements. In models II and III the radio no longer pays for the Foroba Blon service, but receives the payment from the Foroba Blon provider to provide a service. The telecom company provides the phone calls to and from the Foroba Blon platform and receives payment from Foroba Blon provider, so that reporters can use toll free numbers e.g. to enter information in model III, or to receive or access information in Foroba Blon model II.

One of the concerns in ICT4D has to do with the costs of software. Therefore, all software that the W4RA team developed, according to the collaborative approach is delivered and made available as free and open-source software, published[7] including documentation for re-use and further development by communities of developers. We strongly encourage all people who work in ICT4D to make all software available as open-source. This is a way to support the process of innovation and spread of knowledge.

8.5.5 *Validation*

The validation of the used methodology for sustainability assessment was done by the users who gave us frequent feedback and declared themselves satisfied with the results and improvements. Key user of e.g. the Foroba Blon service, Radio Sikidolo in Konobougou, Mali, has used the Foroba Blon system with 50 village reporters, to make radio programs and produce documentaries from neighboring villages. (In 2017 we are still working with Radio Sikidolo on an improved version of Foroba Blon deployed on Kasadaka.)

7 E.g. on http://github.com/nanabaahgyan/RadioMarche (accessed 31-07-2019)

An important goal of the presented approach is to produce ICT services through local value webs that are economically sustainable. Consequently, a sign of success (and an external validation) is where other parties (such as commercial entities) consider the ICT service to be useful and viable. We have several indicators for this. The Foroba Blon ICT service was used by Al Jazeera for monitoring the presidential elections in Ghana and Kenya in 2012–2013. The Foroba Blon service was winner of the News Innovation Contest 2011 from the International Press Institute[8].

8.6 REFLECTION

Based on the results of three scenarios and various business models, we reflect how the *e*^{3}*value* methodology contributes to a better understanding of the sustainability issue of ICT4D services.

HOW DOES BUSINESS INNOVATION WORK IN CONSTRAINED ENVIRONMENTS SUCH AS RURAL AFRICA? From the business models we learn that ICT-service innovation is possible, even in a constrained context such as rural Africa, but only if these conditions are met: (i) there is understanding of the context; (ii) business requirements are developed in concert; (iii) social interaction is taken care of from the grassroots perspective; (iv) potential partners are involved from the start throughout the business analysis process; (v) sustainability for the whole network is evaluated before deployment (see further [26]).

HOW DOES THE APPROACH ENSURE SUSTAINABILITY? From the Foroba Blon pilot we have learned that it is best to start from a legacy system: a work flow that is already in place for an existing (value) network. *e*^{3}*value* proved to be a useful method, even in this context where no ICT-services existed prior to this research project. *e*^{3}*value* makes it possible to evaluate and predict feasibility and profitability for a complete network of collaborating business actors. It enables to calculate or estimate potential profitability, not only from a single business perspective, but for the whole multi-actor value network. It is also possible to design and evaluate alternative business models, do sensitivity analysis and design and evaluate future scenarios using the *e*^{3}*value* methodology. To build realistic scenarios, local business partners and users have to be involved in the process, and real local data have to be obtained.

8.7 SUMMARY

This chapter has proposed a structured, formal method to (qualitatively and quantitatively) assess financial sustainability and feasibility of networked ICT services in low

8 http://www.ipinewscontest.org/news/congratulations.html (accessed 31-07-2019)

resource environments. Such an approach or method is still lacking in mainstream interventionist approaches and sustainability studies on ICT4D. The proposed method is easy to learn and can be used to evaluate networked value constellations in any context.

It is important to note that (i) the exercise of business analysis should be done collaboratively, involving local users and business partners; (ii) the sustainability assessment should go hand in hand with a proper context analysis; (iii) relevant quantitative data are needed to feed the models; the data have to be provided by local stakeholders and business partners.

There are two key points in this chapter. Firstly, sustainability assessment covers the whole network of business actors, not just a single business. Secondly, sustainability assessment can be and must to be done collaboratively, starting at an early stage of an ICT4D project. Having proposed a new approach to assess sustainability of ICT4D in a collaborative, adaptive and iterative way, in the next chapter a synthesis of the collaborative methods is presented, as a theoretical framework and methodology for collaborative, adaptive, iterative ICT4D.

9

SYNTHESIS: A CONSISTENTLY COLLABORATIVE FRAMEWORK FOR ICT4D

Based on experiences from extensive field research, this chapter integrates all components of the field studies into a framework that covers the full lifecycle of ICT innovation, starting from context analysis and needs assessment, through use case and requirements analysis and sustainability assessment, towards collaboratively and iteratively developing, deploying and evaluating the outcomes and impact. The proposed framework includes the intentions (purposes, goals), strategies and methodologies for each aspect and illustrates the collaborative, iterative and adaptive nature of the approach. It shows how the concerns, outlined in Chapter 2 are addressed. With this framework we aim to bridge the gap between the academic/theoretical world of ICT4D research and the practitioners' grassroots perspective and field experiences on ICT4D. Part of this chapter has already been published (see [25]).

9.1 CONSIDERING THE FULL INFORMATION SYSTEMS LIFE CYCLE

This chapter presents a synthesis of the experiences and methods from the previous chapters (in particular from chapters 4 to 8) into one single framework for ICT4D. This is a flexible framework, capable of addressing the general concerns that exist in ICT4D. Using this framework (according to its collaborative approach), requires an interdisciplinary team and good partnerships. The composition and diversity of the team is important and will therefore be discussed. The ICT4D framework itself is presented in two different views: as (i) a synthesis of components and their corresponding methods and techniques, and (ii) a collaborative-adaptive-iterative process model, expressed as an intention-strategy map.

9.2 TEAMS AND PARTNERSHIPS

Since our first field visit it was clear that this field-based research project requires a variety of capabilities and skills. To this end we have brought together an interdisciplinary, multi-cultural team. We include local users, local partner organizations and ICT developers with a diversity of skills and experience in the team.

LOCAL KEY-USERS The core team involves key-users, who are representative for a larger community of future users. Some users give information, others brainstorm and help design solutions; some users set priorities, evaluate, test and validate results. Text-literacy, computer-literacy or knowledge of French/English are not required for

participation in the team. Key-users (men and women) are for example: farmers, village reporters, pastoralists, local entrepreneurs, local experts.

LOCAL PARTNER ORGANIZATIONS Local organizations act as intermediaries between the ICT team and local communities. They are engaged with communities and their problems. They have expertise in local issues. They maintain contacts, organize venues and field visits, translate between languages, organize transport, field visits, and give introductions. As partnerships matter, it is important to build longterm relationships. The organizations we have as our partners strongly support community-based social development, and are inspired by value-driven, collaborative, adaptive development approaches. The following local partners have played a key role in the collaborative ICT4D projects described in the previous chapters.

- *AOPP* – Association des Organisations Professionelles Paysannes is a national Malian association of smallholder farmer organizations. AOPP was established in 1995 and consists of 250 basis organizations (cooperations, village associations, women groups, local youth groups, etc); in total more than 40.000 farmers, fishermen and pastoralists are associated to AOPP. AOPP's aim is to support and improve the livelihoods of its members by representing them in the political dialogue at the national and regional levels and by facilitating knowledge sharing between its members. AOPP bridges the gap between the developers from the W4RA team and the real users: farmers (men and women) in Mali, inviting them to participate in the projects/workshops. AOPP is a partner organization of VU since 2011. (AOPP as an organization did not yet have a website in 2017.)

- *Réseau MARP*[1] is a local NGO in Burkina Faso that aims to promote the participatory action research approach in rural development, in collaboration with local farmers and communities. For several decades Réseau MARP has played an important role in supporting and promoting regreening and farmer-managed natural regeneration in the Sahel. VU has worked with Réseau MARP since it was founded in 1992.

- *University for Development Studies* – UDS[2] is a public university in Ghana, established in 1992. The mission of UDS is to blend the academic world with that of the community, to the benefit of the development of Ghana as a whole, and in particular the rural Northern region where UDS is physically located. UDS has a pro-poor focus, which is reflected in its methodology of teaching, research and outreach services. The specific emphasis on (practically-oriented) community service learning has as goal to contribute to poverty reduction and the acceleration of national development. UDS' mission is operationalized in the "Third Trimester

1 http://reseaumarpbf.org, (accessed 31-07-2019)
2 http://www.uds.edu.gh (accessed 31-07-2019)

Practical Field Programme". In this programme every student of UDS has to do a community-based internship and work in a rural community during a certain period of his/her study. VU has worked with researchers from UDS since the early 2000s in various research and education projects for ICT and (rural) development.

- *Sahel Eco* is a local Malian NGO with headquarters in Bamako and branch offices in Tominian, Sevare and Mopti. In 2011[3], Sahel Eco had about 11 employees, two of which were posted in Bamako and the others working in various regions of Mali, to be able to support the rural communities locally. Sahel Eco gives trainings and organizes farmer-to-farmer visits. Sahel Eco helps to disseminate and improve regreening initiatives, and trains farmers how to improve methods to make a living out of tree products. One of the activities is their support to emerging agro-forestry value chains for small-holder farmers.

LOCAL TECHNOLOGY AND BUSINESS PARTNERS Business partners and technical service providers are often future uptakers of innovative ICTs, and must participate in the team. Examples are community and rural radio stations. These are information hubs of rural Africa, that have a broad coverage in rural West Africa. Various radio stations in Mali and Burkina Faso became closely involved with the W4RA program.

For example: the following radio stations in Mali and Burkina Faso (and various others as well) have contributed to our ICT4D projects (and continue to collaborate with the W4RA team): (i) Radio Sikidolo in Konobougou has been key to the development of various services. Radio journalist and director Adama Tessougué is one of the key users and co-creators of our systems. Other partner radios are: (ii) Radio ORTM Ségou, a national Malian state owned radio; (iii) Radio Moutian, an independent radio in the village Tominian; its staff members collaborated intensively with the W4Ra team in the development of voice services; (iv) Radio Seno in Bankass; (v) Radio La Voix du Paysan in Ouahigouya, Burkina Faso: its staff members have participated since 2010 in our collaborative workshops. Interviews with W4RA members have been broadcast several times at this radio. (vi) Radio Notre Dame in Ouahigouha, and (vii) Radio Solidarité, a small radio station in Ouahigouya, are close partners in our workshops. All these radio stations (and others as well) are commonly involved in W4RA activities to provide ICT services for farmers in rural regions of the Sahel.

9.3 COMPOSITION OF THE FULL ICT RESEARCH & DEVELOPING TEAM

Our research team consisted of local partners, ICT developers and researchers. Various roles have to be represented. One person can represent more than one role. People can switch between roles.

3 At the time of the start of the VOICES project.

Figure 65: Field visit to farmer and regreening champion Moussa Sangara, during a 12-day roadshow in West Africa, near Bandiagara, Mali, January 2011. Photo: Bruno van Moerkerken.

- A project manager, to manage and organize an international project; this person should be able to take decisions over resources, finances etc;
- A requirements engineer/information manager, for bridging the cultural distance between users/developers, moderate sessions;
- An information analyst to translate the user stories into concepts and processes and build conceptual models of the elicited information/knowledge;
- One or several context experts, preferably from the region, or with extensive local experience;
- One or more ICT developers with hands-on skills, able to build rapid prototypes, apps, interfaces, and able to explain this to non-technical people;
- An ICT-business requirements & service expert, who can evaluate and model business information and safeguard long-term sustainability issues;
- If the users are low-literate, voice technologies must be considered, and voice-technology skills are required in the team;
- A filmer/photographer to record all meetings, and able to produce documentaries for further use and dissemination;
- One or several local contact persons who maintain daily contacts with the user communities, translate to and from local languages, explain the local context and chair the meetings;

Figure 66: Defining priorities during co-creation workshops with farmer organization AOPP in Mali, October 2015.

- A driver, because the project requires long drives, usually by bus, with many people;
- One or more local ICT business partners or service providers, able to learn new skills and help deploy the systems;
- Key users: farmers men and women, extension workers who work in the communities, herders, local sales persons, farmer-innovators.

9.4 A CONFIGURABLE FRAMEWORK

In Chapter 4 concerns are discussed that are characteristic for what we refer to as a "low-resource environment". These environments are found e.g. in rural regions of the Sahel in West Africa. To address these concerns in a user-centered way, taking into account the needs and objectives of local users, we proposed *collaboration, adaptation and iteration* as an alternative to the mainstream top-down interventionist approaches that focus on transfer of knowledge and technologies from the Global North without notion of emergent innovation, local agency, and complexity of local contexts.

In chapters 5 to 8, the adaptive approach was illustrated by various pilot studies in rural Africa. Based on the field experiences and an iterative learning approach, we make a synthesis of all methods and techniques into a flexible framework that describes how to develop ICT-enabled services for people in low-resource contexts.

The proposed framework consists of five components or aspects as summarized in Figure 67: context analysis (i), needs assessment (ii), use case and requirements analysis (iii), sustainability assessment (iv), engineering, deploying, evaluating (v).

Because of its adaptive and iterative nature we refer to the framework as a configurable list of 'components' rather than a series of sequential 'phases'. In practice the framework components heavily interact with each other, instead of being applied in a traditional, top-down waterfall approach or logical framework approach. How the

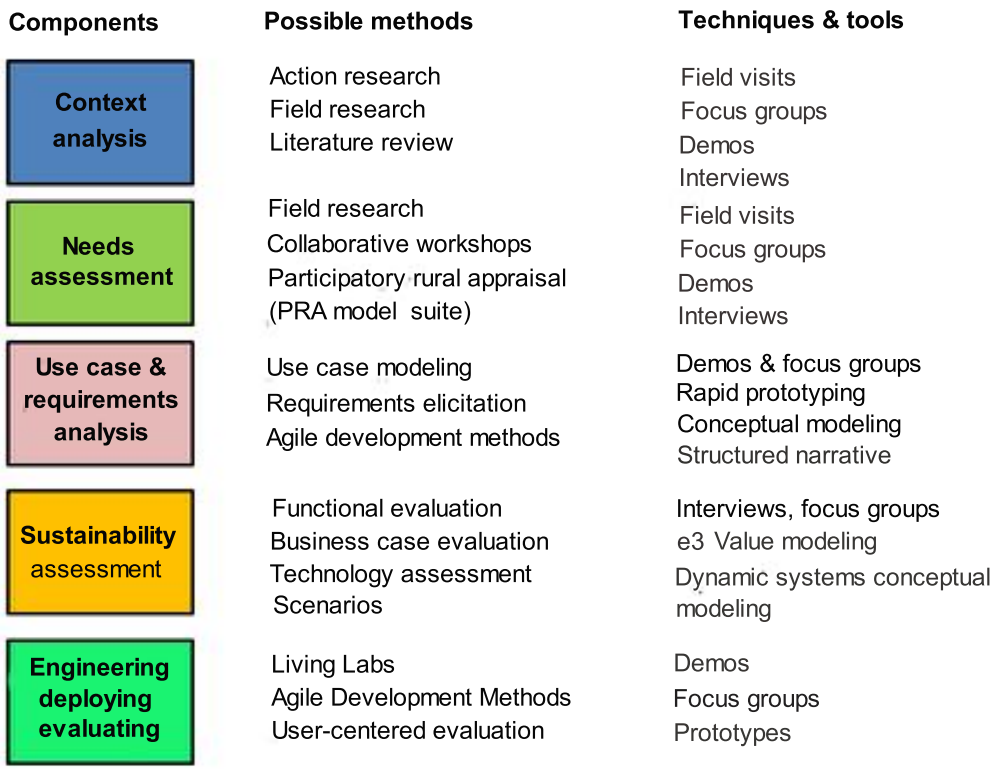

Figure 67: A consistently collaborative framework for ICT4D with five components and corresponding methods, techniques and tools.

framework caters for the concerns of ICT4D in low-resource environments, is described in the following paragraphs.

- *Context analysis,* as described in Chapter 4 and illustrated by examples from our research in the Sahel in West Africa, is one of the key aspects of ICT4D and one of the components of our framework. This aspect is often overlooked in mainstream ICT4D projects, based on an (unwarranted) assumption that technology will work irrespective of context. Context analysis is called for in our framework for two important reasons: (i) to bridge the big gap between technology and developers on the one hand and the world of the end-user on the other hand; (ii) because of the contextual nature of ICT and information systems themselves. Context analysis consists of field visits (see e.g. Figure 65), road shows, focus group discussions, interviews and technology demos. It is based on field-based action research.

- *Needs assessment,* presented in Chapter 5 and illustrated by examples from collaborative workshops with farmers and rural communities in Mali, Burkina Faso

and Ghana, can be described as a method for collaborative goal construction (see e.g. Figure 66). Needs assessment, as an aspect of our ICT4D framework is a two-way, iterative process, which consist of several phases (i) jointly exploring the problem space (ii) jointly defining the solution space (iii) selecting the best key ideas, setting priorities, evaluating and jointly deciding which ICTs should be further elaborated. Needs assessment workshops make use of collaborative techniques for knowledge elicitation (living labs, ba, participatory technology development etc.).

- *Use case and requirements analysis.* Use case and requirements analysis and elaboration constitute an important aspect of the ICT4D framework and often overlooked in mainstream ICT4D projects. We propose a method to structure the collected data from the field research/workshops, presenting this in different views: (i) in formal technical specifications, that allow the ICT developer to design the architecture and build the system (ii) in a narrative and informal way to make sure the end-user can validate requirements and understand and discuss the technical idea/design. The method we propose is coined "structured narrative method". This method and its corresponding format are explained in Chapter 6 through an example of a mobile ICT service for farmers in Mali.

- *Engineering, deploying, evaluating in a collaborative approach.* In Chapter 7 this collaborative process is described and illustrated through an example of an extensive ICT4D project in rural Mali. This case shows how such an ICT4D project can be carried out and why an adaptive, iterative approach is required when coping with innovation and complexity of the local context. The case shows that many questions are still open. More interdisciplinary field research is needed to improve the outcomes of ICT4D.

- *Sustainability analysis.* A method to perform sustainability analysis in a structured and formal way is presented in Chapter 8. This method uses field research data to build scenarios and calculate business models for all actors in a value network. This sustainability analysis, which is based on the e^3*value* methodology, makes it possible to evaluate sustainability of an ICT service from the start of the ICT4D project, i.e. before deployment. It allows to anticipate and adjust the ICT4D project, during the project period. The collaborative aspect of this sustainability assessment method is that it evaluates sustainability and profitability for all actors in the value network. In this it differs from other business modelling tools that commonly evaluate profitability from one single entity/business perspective. This method of sustainability assessment has not previously been used in ICT4D.

9.5 HOW THE FRAMEWORK ADDRESSES THE CONCERNS

This chapter has outlined a framework for ICT4D. As discussed in Chapter 4, *any* such ICT4D framework should be able to address a set of important concerns that we summarized under the label *low-resource context*, and that are widely and commonly encountered in developing and emerging countries. Below we sketch how these concerns are addressed in our proposed ICT4D framework.

LOCAL NEEDS UNKNOWN. This is, we believe, the core issue for any real-world adequate ICT4D framework. Namely, the domain is rife with generic statements on the progress that ICT can (or even will) bring for development and more specifically for 'the poor', in alleviating or even eradicating poverty (see the opening sentences of this paper, the United Nations Millennium Development and Sustainable Development Goals, Jeffrey Sacks' neoliberal Millennium Village Project [273], or much of the ICT4D policy literature (cf. [140] as a typical example)). Our point is that such statements have noble intentions, but are scientifically speaking no more than hypotheses about the *possible* importance of ICT, and so they need to be put at the test as any scientific hypothesis. This is however rarely done, or if so it is done from a big distance through desk research. In our view, this is far from good enough. Therefore, our framework reserves a special place for *needs assessment* clarified through local field research that takes place on-the-ground and at the grass-roots level in a collaborative fashion akin to action research.

CONTEXT UNKNOWN. Information needs of people do not emerge and exist in isolation. Instead, they are situated within the specific contexts of people's everyday work, practice, life. The more this is different from the mainstream ICT developer context (certainly if the latter is from the Global North, as is often the case), the bigger the need to study it in detail. Hence, our framework includes extensive *context analysis* that is again in-the-field, on-the-ground at grassroots level. In other words, academic desk research carried out at-a-distance as is often done in a development context is inadequate: again, it usually involves hypotheses that are scientifically untested in the Global South but are uncritically accepted by quite a many in the Global North.

SIGNIFICANT LEVELS OF LOW-LITERACY. This issue impacts heavily (also) on the technical ICT solutions that are entertained in the *engineering, deploying and evaluating* component of our framework. The Internet, World Wide Web and the use of social media, as well as the use of SMS in mobile phones, are heavily biased towards text, and so in fact discriminate against those who cannot read or write. Field research into this typically triggers the correction of such text biases and the prioritization of non-text solutions such as voice services.

AVAILABILITY OF CRUCIAL TECHNOLOGY AND INFRASTRUCTURE. Policy statements (and similarly, big-company attempts) make it often seem easy to resolve issues such as affordable Internet for everyone everywhere. In contrast, the reality on-the-ground is that electricity is already a major issue that is not going away easily, especially in the rural areas where most of the poor live. So, any real ICT4D project has to shy away from (vaguely) stating what might be possible in a distant future, and is to start (realistically) from *what is there already now*. This again underlines the importance of empirical field research in ICT4D.

LOW PURCHASING POWER OF END-USERS. This is a given that especially impacts the durability of ICT solutions beyond initial project development and piloting. Hence, in our framework it is factored into *sustainability assessment*, and in particular made explicit through the e^3*value* methodology focused on the value network of stakeholders' balance of benefits and costs that we have introduced in this paper.

LACKING UNDERSTANDING OF ICT POSSIBILITIES. This is a common problem also in the Global North with non-ICT users. Our experience is that this problem can be quite well overcome within field research by properly designed demos and roadshows that are tailored to the specific interests of relevant local audiences. A key criterion is that technical demos and associated explanations are such that people can imagine for themselves how technological possibilities and affordances might work out in their own situation.

MISMATCH BETWEEN DONOR GOALS AND 'BENEFICIARY' END-USERS. This is a concern quite specific for ICT4D. In the Global North it is typically the end-user company that ultimately pays the bill in ICT projects. This is also the assumption in the Agile approach to software engineering. In ICT4D this is however typically split: projects are structured according to donor and sponsoring funding agency ideas and goals about what are assumed to be the (supposed) beneficiaries' ("the poor") goals. Commonly, there is a big difference between the two and, minimally, such donor goals go untested against the reality in the supposed beneficiaries' context. Our framework provides an antidote to these biases by its emphasis on collaborative field research in all the ICT stages.

SUSTAINABILITY CONCERNS. It goes without saying that anyone would like an ICT development to be successful for many years, also after initial project development and piloting. We have introduced novel methods for sustainability assessment in this paper. Often, in the conventional monitoring and evaluation (M&E) approaches in development, this is studied after the fact, when it is in fact too late (not only post hoc but even post-mortem). Instead, we propose in our framework to perform sustainability

assessments at an early stage, such that the associated what-if scenario analyses can impact ICT development at the early design stages.

9.6 A PROCESS MODEL FOR ICT4D SERVICE DEVELOPMENT

Now, if we integrate the various components and aspects of our ICT4D framework (cf. Figure 67), and formulate the exposition and case examples of the previous chapters in a generalized fashion, we obtain an overview picture as in Figure 68. It gives a process model of our ICT4D service development framework in the form of an *intention-strategy map* [243, 265], a technique stemming from goal-oriented requirements engineering[4]. Here, ovals denote intentions (goals), and arrows denote strategies to achieve these goals. In a single phrase, the framework for ICT4D service development is collaborative, adaptive and iterative throughout.

Some of the above-mentioned concerns and the ways our framework addresses them might seem pretty obvious and straightforward. Indeed, some of the mentioned concerns are also an issue in the Global North (such as the gap between ICT-developers and non-ICT end-users), and many suggested methods are already in existence (although the sustainability assessment methods we propose are novel). Within the ICT4D literature, there is a (limited) number of authors pointing in similar directions as we do, often from a human-computer interaction (HCI) perspective [22, 77, 78, 231, 232, 306]. Notwithstanding this, this book shows that ICT4D is not just ICT business-as-usual. We offer three reasons for thinking so:

1. There is no denying that the concerns to be resolved in ICT developments are much more severe, critical and constraining in the case of ICT4D, and this on a very broad front, social as well as technical. What initially are matters of degree at some point combine and then turn into fundamental qualitative differences.

2. Perhaps surprisingly, many modern developments in software engineering, computer science, and information-systems practices, that are by now taken for granted by scientists and professional specialists, still escape the attention of the development circles that fund and drive (also) ICT projects.

3. More fundamentally, our observation is that a lot of external (mostly western) bias is commonly introduced into ICT4D projects. Many of these biases originate from uncritically adopted assumptions, by upfront presuming many things about stakeholder goals, needs, technologies and their context. The basic problem here is that often these presumptions are not critically tested against developing countries' realities on the ground, in order to see whether they are actually warranted.

4 For a full account on mapping of purposeful systems, see Colette Rolland (2007)"*Capturing System Intentionality with Maps*" [265].

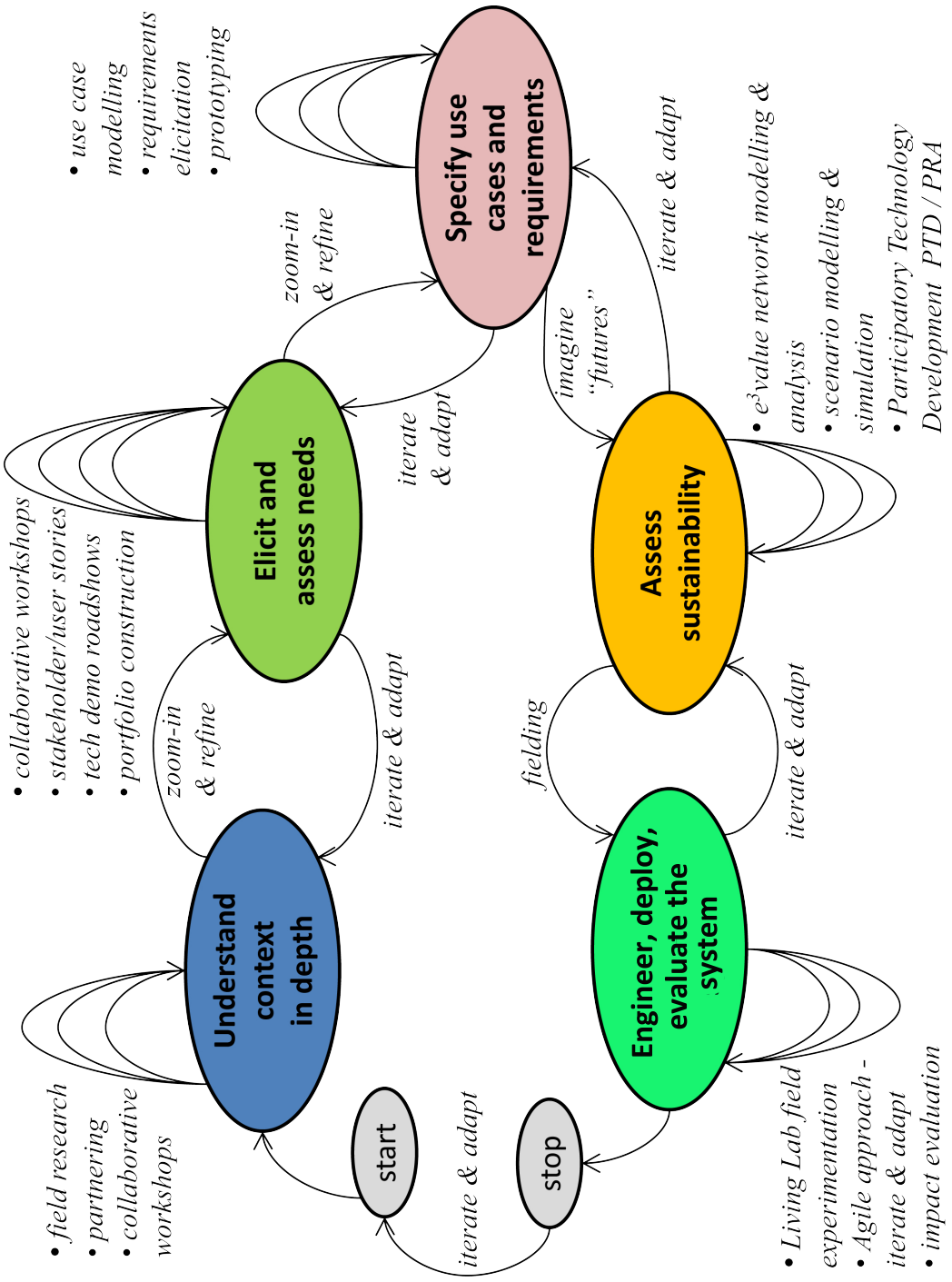

Figure 68: The collaborative-adaptive-iterative process model for our ICT4D Service Development framework, expressed in the form of an intention-strategy map.

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9.7 A CONSISTENTLY COLLABORATIVE FRAMEWORK FOR ICT4D

In this chapter we have proposed an ICT4D service development framework and methodology, which is thoroughly and inherently *collaborative, adaptive and iterative*, throughout the whole development lifecycle. It puts emphasis on (i) the composition of the interdisciplinary and multicultural team and (ii) the importance of the early upstream stages of ICT systems development. It emphasizes needs analysis, in context *'sur le terrain'*/'on the ground' – even before ICT technologies are necessarily being implied. The reason is that inherently sociotechnical systems such as ICT4D services have a heavily *contextualized* nature: the 'known unknown' that requires extensive field-based research.

Part III

REFLECTIONS

[in which we reflect on innovation, collaboration and context, and argue that a networked approach is the most appropriate way of coping with complexity. Next, we reflect on the inherently value-laden aspects of poverty, livelihoods, and interests and how this can be addressed in ICT4D.]

10

ICT4D = INNOVATION COMPLEXITY ≠ INTERVENTION

In the previous chapter an operational approach to ICT4D, dubbed 3.0, has been introduced that is collaborative and addresses local needs and context. In Chapter 2 we have discussed technological innovation and its diffusion as a complex non-linear process, in which actors exchange knowledge in social networks and diffusion occurs in rather unpredictable ways. In this chapter we discuss what makes an operational approach to ICT4D capable of coping with this complexity, from the perspective of innovation theory, putting forward the notion that any ICT4D action entails a fundamental process of sociotechnical innovation. We will introduce complexity theory and discuss farmer innovation in the Sahel and the possible role of ICTs in scaling communication and knowledge sharing as a complex adaptive system.

10.1 THE INNOVATION DIMENSION: ITERATIVE, ADAPTIVE, COLLABORATIVE

To understand complex, networked processes of innovation, this chapter will focus on the characteristics of the actors, their context and their interactions. What drives people to innovate? How do they learn? How does communication and exchange of knowledge work? How are resulting artefacts used in practice? How are requirements found, in order to match user needs? To answer these questions, connections are made with existing theories of innovation.

10.1.1 *Innovation: top-down or networked?*

In Chapter 2 the linear, top-down model of innovation has been discussed: a model still dominant in international development cooperation. According to this model, innovation starts with an inventor, generating an idea or doing an invention. This is followed by a phase of research and development, located in high-tech laboratories, followed by a phase of large-scale manufacturing. When ready, the roll-out takes place in developing countries. This model, which is conceptually visualized in Figure 69, has been described by Joseph Schumpeter, A.P. Usher, Everett Rogers and others [285, 312, 263]. The way the OLPC (One Laptop per Child) project was designed and deployed is an example of the linear, one-directional transfer of technologies innovation model.

Yet, various studies have criticized the linear model of innovation for being incomplete and unrealistic, and for not explaining certain phenomena which are observed in innovations [308, 158, 168]. Alternative theories of innovation show the important role of users, social networks, and communities of practice in innovation processes. These theories are based on innovation studies in various different contexts: high-tech

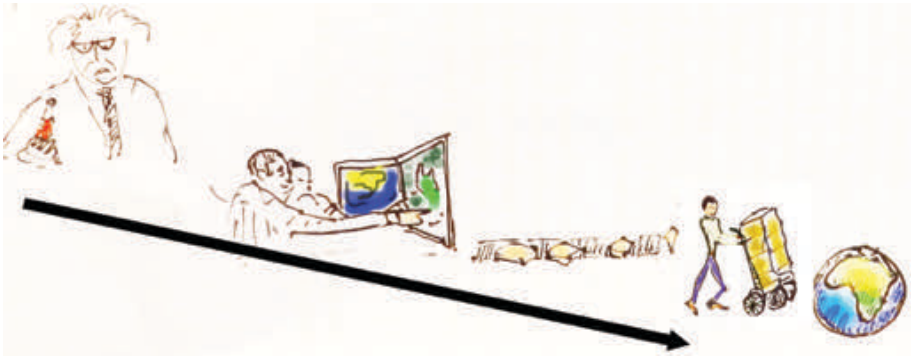

Figure 69: The linear, one-directional model of innovation for development, from inventor and research & development to production, and roll-out at large-scale in developing regions.

environments e.g. [308, 319, 320, 103, 158, 168] as well as low-resource, low-tech environments, in developing regions [251, 70, 69, 202]. The networked approach as a more effective way to deal with complex contexts and problems, has been proposed in various studies [15, 36].

User-induced innovation, unanticipated ways in which users re-invent technologies, interaction and two-way communication between developers and users are aspects which are not mentioned in the linear models of innovation [319, 319, 320, 251]. Whereas linear models focus mainly on the economic aspects of innovation, they tend to entirely overlook social learning, cultural aspects and e.g. the importance of 'meaning' [57, 167, 308]. In the next sections several cases from literature will point at the (social) networked aspects of innovation.

10.1.2 *ICT4D as innovation*

As discussed in Chapter 2, large similarities exist between complex adaptive systems, social networks [198, 197] and diffusion of innovation models [264]. People in social networks interact, exchange knowledge and build social networks with strong and weak links, and feedback loops. This leads to emerging patterns of (decentralized) aggregated behavior, as a complex adaptive system. Diffusion is the process in which innovation is communicated through certain channels over time along the members of a social system [263]. Innovations are technologies, ideas, artefacts, practices which are adapted, reinvented and adopted, while they are being diffused.

As briefly discussed in Chapter 2, innovation researcher Everett Rogers, in his book "Diffusion of Innovations" gave the characteristics of decentralized diffusion systems: (i) much diffusion is unplanned and uncontrolled, there is a wide sharing of power and control among the members of the social group (ii) diffusion occurs peer-to-peer through horizontal networks; (iii) innovations come from experimentation by non-

experts, local units decide which innovations should diffuse on the basis of informal evaluations of the innovations ; (iv) there is a problem-centered approach, technology pull, created by locally perceived needs and problems; (v) there is a high degree of local adaptation as they diffuse along adopters [263].

Rogers compared the processeses of decentralized diffusion of innovations with those of highly centralized, top-down interventions. He perceived that decentralized systems are more likely to fit users needs and problems, as users feel a sense of control when they participate in making key decisions, for example, about which of the perceived problems most need attention, which innovations meet these needs, how to seek information and which information sources to select ([263], p 398).

10.1.3 *Users influencing innovation*

An example how users influence an innovation process in unanticipated ways, creating and giving meaning to a technology within their daily practice, is the introduction of the telephone, before World War II [103]. The telephone, originally introduced in the United States as a top-down broadcast medium to centrally inform customers, has grown out to be the most important tool for social interaction until present day [103]. Claude Fischer describes how users have influenced this new technology:

> *"... Users are represented in negotiations that reshape innovations and channel their use by interest groups and ultimately by the purchase decisions of individual consumers and the actual use to which those individuals put the technology. By this process, the telephone is transformed in something different. In the case of the telephone we see how AT&T leaders, pressed in part by consumers, eventually tried to redefine their product from a totally practical service into a 'comfort' a 'luxury' of the modern lifestyle. Most social constructivism has concentrated on the producers, marketers or experts of a technological system. I intend to go further [...] to the point at which the final consumers choose, employ and experience a technology" [103]*

Another example of user-driven innovation and unanticipated use, is the emergence of the World Wide Web, which went viral since the early 1990s. This process is studied by Illka Tuomi as an example of collaborative innovation [308].

The design of the World Wide Web was made by Tim Berners-Lee at the European institute for nuclear research CERN. It was originally set up as an information exchange platform for nuclear scientists. Its design was so simple, that Tim Berners-Lee's proposal was rejected several times by the management of CERN before it was recognized as useful [308]. The presumed weaknesses of the design became eventually its strengths. The design's simplicity and flexibility, the lack of a central coordination, the absence of authentication mechanisms or security made the system vulnerable, but also replicable on any computer connected to the Internet. The lack of a central content management system was at first regarded as a weakness. It made it difficult to

find documents, due to a lack of directory structures. The problem of finding content was later solved in a much more efficient way by the emergence of powerful search engines. The simplicity of the hypertext markup language HTML enabled millions of users around the world to create web pages and publish their own content.

The lack of security in the Web's design has later been solved by others, who introduced encryption to secure data and enable commercial transactions and e-business on the Web. The exponentially increasing computer power, disk capacity and network bandwidth, following Moore's law [200] of doubling capacity roughly every two years, made it possible to start massive exchange of data-intensive applications such as videos, games and music. The Web was continuously expanded and re-invented through the innovative and creative capacity of millions – users, developers, entrepreneurs. The open structure and flexible design of the Web combined with unanticipated use and re-invention of technologies made the Web become the largest human information network until present day: a platform for online shopping, for social interaction, for the exchange of home-made videos of cute cats.

10.1.4 *Evolution of a high tech innovation: mobile*

Mobile telephony is the largest and fastest technological innovation ever deployed in developing countries. Currently, in Africa 81 out of 100 people have a cellular subscription, where this was only 4 out of 100 inhabitants in 2002[1].

Mobile phones can be observed, even in very remote rural areas. During our field trips from 2009 - 2018 in West Africa, we often spoke to mobile phone users in rural villages, where there is no electricity e.g. Zanlerigu, Yameriga, Tongo-Beo (Ghana), Ranawa, Minima Durga, Basi (Burkina Faso), Kokele (Mali). Despite the technical constraints, the majority of people use mobile phones on a daily basis. On the streets a dynamic eco-system of small-scale service providers can be observed: small shops where you can buy phone credits, (sap-sap), charge your phone battery in creative ways: with small solar panels, or car batteries. In Ranawa, Burkina Faso we met a 'mobile mobile' recharger, a person who traveled from village to village to charge phones with his motor cycle battery, which provides him with income. (Figures 70 and 71).

Anthropologist Lotte Pelckmans studied mobile phone usage in Mali. She described innovative ways in which the phone is used in Mali: *"... an example of local context-shaping phone use in, for example, West Africa is the practice of 'flashing' (in French: biper). It entails calling someone with the sole purpose of making the phone ring, without expecting the other person to answer"* [227].

The mobile revolution generated business in the formal and informal sectors in Africa. According to the GSMA[2] Mobile Economy Report 2015, the mobile eco-system

1 Source: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf, (accessed 31-07-2019)

2 GSMA is the Groupe Spécial Mobile, the world association of mobile operators.

Figure 70: A 'mobile' entrepreneur in front of his shop, near Gourcy, Burkina Faso, June 2016.

in 2014, provided 4.4 million jobs in the whole of Sub-Saharan Africa, of which 2 million were official resellers. This figure is probably a low estimate of the total number of jobs, if we consider the large, informal economy in developing regions: battery charging providers, second hand handset vendors and other creative street business that have emerged in the past few years [76].

Mobile telephony in Sub-Saharan Africa is not the same service as in e.g. Western Europe. While in industrialized countries 4G networks have massively deployed for SmartPhone use, in West Africa first generation – the simple voice-based GSM phone – still accounts for 90% of connections[3]. Mobile service was subject of many adaptations, since its take off in urban middle-class settings in the early 1990s [191], until it became accessible for low-income users in e.g. rural Africa.

Mobile telephony was initially positioned as a luxury commodity, an expensive complement to the fixed line phone [157]. Prices of phone handsets were high, more than 100 US$. Subscribing to a mobile service required a contract, a mobile phone purchase, 12 or 24 monthly service obligations, usage charges, and a connection fee, including, often, a credit check to ensure liability of the customer [157]. Adaptations of the service towards low-income groups occurred gradually and iteratively. Once financial and technical barriers had been removed, roll-out took off in developing regions.

The introduction of prepaid SIM cards in 1992 was a remarkable (supplier-side) innovation in the mobile service [38]. Prepaid consists of an inexpensive SIM card (in Mali a SIM card or *puce* for the Orange or Malitel networks costs less than one euro, and can be purchased on the streets, without name registration, still in 2014). The SIM can be topped up with prepaid phone credits. The top ups can be small: e.g. 50 cents to a few euros. Prepaid allowed people without steady income to own a phone without subscription or contract.

3 Source: GSMA report Mobile Economy Sub-Saharan Africa 2015, https://www.gsma.com/r/mobileeconomy/sub-saharan-africa/,(accessed31-07-2019)

Figure 71: Mobile businesses in Burkina Faso, (left and middle: 2009, right: 2016.)

The prepaid system, which consists technically of storage and billing software only, was first launched in Mexico in 1992 during the financial 'peso' crisis. Soon this proved its value in other parts of the world. Apart from success on the user side, prepaid reduced financial risks for the mobile operators and the time consuming distribution and billing tasks, leaving this to small local entrepreneurs and street vendors, which created new local (low-income) jobs. By 2006 the prepaid had become a leading mobile business model in the world [191].

Lack of electricity in rural regions was another barrier to mobile roll-out. For network operators it raises the investment costs for deployment of new GSM cells. The problem of charging the users' handsets was solved by local creativity, of mobile rechargers and other informal phone services (see e.g. Figure 71).

While several (technical, financial, organizational) barriers to mobile adoption were step by step removed, mobiles came increasingly in the reach of low-income users, first in urban and gradually in rural regions. The continuous migration between urban and rural areas in Africa may have contributed to the diffusion. Meanwhile, prices of GSM handsets (by Nokia, Ericsson, Motorola, LG, Samsung) went down. Small and large, formal and informal businesses entered the mobile market [157].

As became clear from various interviews we did with low-income users in Ghana, Burkina Faso and Mali, phone brought advantages of remote communication for those who had been hitherto unconnected. The technology was easy to learn and use, and affordable to a certain extent. The phone was used in creative ways, flashing, beeping to save credits. While mobile money was not yet introduced, sap-sap (transferring credit remotely from one phone to another) was used as a sort of payment channel by phone users in Burkina Faso, transferring credit to another phone as a payment[4].

The number of phone users continued to grow in Africa, in the early and mid-2000s. Mobiles became more valuable when numbers of users started to increase, creating a self-amplifying feedback loops accelerating its diffusion (this network mechanism

4 Personal communication Mathieu Ouedraogo, September 2009.

is discussed by e.g. Rogers (2003) [263], and Monge & Contractor (2003) [198]). Because of the high cost of rolling out the GSM infrastructure in rural regions of Africa, while this roll-out depended on investments by the private sector (telecom operators), user adoption and network expansion occurred iteratively. Competition between mobile operators, induced by regulation authorities (which were established in African countries in the late 1990s)[5] resulted in a competitive telecom market, with often four, five or more operators. This competition was an incentive to expand networks to rural regions. The forecasts for further expansion of mobile networks in rural regions in Sub-Saharan Africa are currently less optimistic. According to the GSMA report for Africa 2015:

> *"The majority of unconnected people in Sub-Saharan Africa live in rural and geographically remote areas. The main challenge to extending mobile broadband coverage to the unconnected is the cost of rolling out and maintaining network infrastructure in thinly populated areas where the majority of consumers are typically on low incomes... A factor limiting subscriber growth is the relatively weak business case for rural network rollout; low average revenue per user (ARPU) for rural consumers makes it hard to justify high costs of network deployment and maintenance in remote communities."*

According to the GSMA, in 2014 the direct GDP contribution of the mobile ecosystem in Africa was 43 billion US$ or 2,4 % of GDP. This is calculated as the total income generated by the industry to its employees, through payment of wages, government taxes and shareholders (in the form of profits). From this amount 70 % goes to the (multinational, mainly non-African) network operators. The other 30 % goes to content and application providers, retailers, infrastructure providers and handset manufacturers.

As becomes clear from this brief account, the evolution of mobile telephony in Africa was influenced by different players, with different roles and interests. Its unpredictability is illustrated by the late recognition from the international development community[6]. From the mid-2000s on mobile telephony was acknowledged by researchers and policy makers as transformative technology for development [1, 76, 154, 204, 237].

One of the unforeseen impacts of mobile telephony was the emergence of another innovative service: mobile money, which became a huge success for the private sector and therefore rolled out rapidly.

5 Induced by neoliberal policies and the World Bank.

6 In the early 2000s, leading policy papers like UNDP Human Development Report 2001 [65] and the World Summit for the Information Society: http://www.itu.int/wsis/docs2/regional/outcome-accra.pdf, (accessed 31-07-2019), marginally mention mobile telephony as a tool for development, focusing mainly on computers and Internet. The WSIS Plan of Action (2003) and the WSIS documentation (2005) contain few references to mobile telephony.

10.1.5 *Mobile money*

Mobile money is an innovation that started in Africa. The widespread availability of mobile phones made this possible, as a critical mass of users is needed to make this service successful. The first mobile money service was M-Pesa (pesa is the Swahili word for money) a service which allows users to deposit money on a cell phone, and/or transfer it to other users of the service. It allows to cash it back to currency from a network of agents, airtime resellers and retail outlets acting as banking agents. Users are charged a small fee for each transfer. M-Pesa has become a banking service for millions in Africa who never owned a bank account before.

Mobile money was introduced in Kenya in 2007 by the local mobile operator Safaricom. M-pesa registered 1.1 million users in the first eight months after its inception, while an amount of US$ 87 million was transferred over the system. By September 2009, 8.5 million Kenyans had registered to use the service. In 2013 this was 17 million, two-thirds of Kenya's adult population[7] [194].

After the success of M-Pesa in Kenya, new mobile payment systems popped up in many other countries in Africa, offered by other mobile operators such as Orange, Vodafone, Airtel, MTN.

The diffusion of mobile payment systems was a spin-off of the mobile revolution. The advantages perceived by users were: the ability to store and transfer money at distance – e.g. remittances [233], the perceived compatibility with existing values and payment habits, its simplicity to learn and operate, its triability and observability using interpersonal communication channels [263].

Mobile money has shown social impacts. According to Mbiti and Weil *"only a decade ago, family members in different parts of Kenya had a very limited scope of communicating with relatives from distant parts of the country, and faced difficulties in sending and receiving remittances. Now, in many cases, money can be transferred almost instantaneously"*. M-Pesa has enabled small businesses to expand and has increased the circulation of money in small communities [233]. The cases describing the emergence of mobile service and web show the role of users and their unanticipated ways of using technologies. It also shows how manufacturers and service providers adjust their marketing strategies according to progressive insights into users' preferences.

The above examples of mobile telephony and mobile money show that high-tech technologies can rapidly spread, also in a very constrained low-tech environment. The success of mobile telephony has often been used as an argument why ICT4D should work, and why the Internet should be rolled out by the private sector, as happened with mobile services – and if necessary with financial support from the public sector.

At the customer side, diffusion will only occur when certain conditions are met (the new technology brings a relative advantage; its compatibility with local practices such as language, illiteracy; its affordability, etc). At the supplier side the provisioning only

7 Source: http://tinyurl.com/o59nw6t

occurs when a technology can be easily deployed and scaled up, and when the average revenue per user (ARPU) is sufficient to justify investments for scaling up, against quick profits (at the so-called "fortune at the bottom of the pyramid" [237]) which are in it for the private sector. In case when higher investments are needed to kickstart the innovation process, the international private telecom sector no longer acts as a vector for innovation. In that case public investments and ICT4D research are needed.

10.2 TWO-WAY COMMUNICATION: DEVELOPERS – USERS

The linear model of innovation is based on the assumption that the source of innovation is 'upstream', at the loci of the inventors, researchers, developers or manufacturers [308, 319, 320]. It draws the physical or conceptual (geographical, cultural) barrier between the upstream (inventor/manufacturer) in the wealthy Global North and the downstream (passive customer, user, beneficiary) in the 'receiving' or developing country, implying a one-way information flow, downstream. It does not acknowledge or support a two-way interaction interface between developer and user. The information from communities of users is not used for (re-) design or further development. It does not feed the inventor with new contextualized knowledge.

Also in ICT/software development projects in the western world, a one-direction linear approach, named the *waterfall model*, was widely used. In the 1960s and 1970s this was the common approach to centrally plan and control software development projects [85, 302, 124, 256, 328]). The waterfall model is still used in many software development trajectories in large firms and governments.

Over the years, the linear waterfall model – in which the information analysts and software engineers talk mainly to bosses and project managers, but do not have access to the actual users – has been held responsible for high rates of failure in large-scale ICT projects. Failure is attributed to lack of real end-user involvement. This leads to incomplete requirements/specifications, because user requirements tend to change during the development process [181, 185].

From the 1990s on, adaptive, iterative methods have been introduced in software development as a response to high failure rates of linear models [124, 256, 328]. User-centered spaces of innovation have become fashionable, such as living labs [146, 129]. Users are involved in early stages of the design process. They are observed in their own natural environment, performing normal tasks which are difficult to explain in words, but easy to demonstrate on the spot. Creative techniques such as rapid prototyping and extreme programming are often used[317]. These are methods for building prototypes or demos in a short time span (e.g. one day), sometimes even in the presence of the end-user, to show them the basic idea and check if the requirements have been well understood by developers and users.

Another improvement in software development is the introduction of self organizing teams. These teams are usually non-hierarchically organized, team members have

high commitment and team spirit and creativity are highly valued. An example of this method are scrum teams (a term borrowed from rugby) [259]. These methods are usually grouped under the large umbrella of *agile* development methods. [85, 302]. Agile methods are a set of principles how innovation and software development can be done, rather than a suite of cook-book recipes. Adaptation to context and end-user involvement are central to agile methods. Agile methods are widely used in ICT projects in western countries [190, 296, 295, 169, 121]. However, in the execution of international development programs and projects, including ICT4D, agile methods are still uncommon.

10.3 UPSTREAM – DOWNSTREAM

As previously remarked, in innovation for development – including ICT4D – the gap between the upstream development and downstream 'passive adopter or user', has as implication that it tacitly attributes a 'superior' role to 'western' technology and 'scientific' knowledge, in comparison to downstream, indigenous knowledge and innovation capacity of local communities. This attitude is observed in many domains of innovation for development [54, 52, 37, 263, 251, 57]. As a consequence, local knowledge and context are often overlooked by the development experts.

An example of a typical linear innovation project that failed because of overlooking local knowledge systems, occurred in Bali, Indonesia, during the Green Revolution [173]. The Green Revolution was a global-scale intervention programme, rolled out in Asian countries in the 1970s [235]. It aimed at increasing food production for growing populations through a rapid introduction of genetically modified seeds, fertilizers and pesticides, at very large scales [173].

In Indonesia and other Asian countries the Green Revolution was a nation-wide operation supported by the international community and the agro-technology industry [235]. It consisted of large-scale transfer of technology, aimed at speeding up and facilitating the transition from subsistence farming to intensified agriculture. The approach was typical for large-scale interventions without any notion of adaptation to specific local conditions [292, 116]. For example, in Bali, farmers were summoned to abandon traditional farming and use new, subsidized technology packages that were available through extension services [173, 174].

10.3.1 *Traditional knowledge in Bali*

Shortly after introduction of the Green Revolution, rice harvests in Bali were plagued by increased pest outbreaks [173]. Rice harvests were seriously threatened and damaged. Balinese farmers complained that new development plans were creating unprecedented problems in water scheduling and pest control [177].

In 1983, two researchers, Stephen Lansing and James Kremer discovered an ancient system of wet-rice farming in Bali, which was coordinated in a distributed way by cooperating rural communities, named 'subaks'[173]. This complex agro-ecological system consisted of an intricate system of canals, rice terraces, and irrigation works linked to a network of water temples and shrines. Through a symbolic system of temple rituals, the cooperating subaks were able to coordinate complex tasks in their production of rice and pest control, including allocation of irrigation water, and scheduling of seeding and cropping [174]. The temples and shrines, dedicated to the Goddess of the Crater Lake and other local agricultural gods, and their religious events and feasts, were pivotal in the effective management of water and the synchronization of cropping and harvesting calendars between the various rice paddies and subaks [173].

The study by Lansing showed how the complete system had been developed over the course of centuries by cooperating farmers who gradually engineered the landscape of their island, cleared the forests, dug irrigation canals and terraced hillsides to grow irrigated rice. Doing so, the subaks succeeded in optimizing production and created resilience in the ever-changing environment, in the absence of a central controlling mechanism [173, 174]. In parallel to the physical labor, they constructed networks of water temples and shrines [175]. The system of ritual technology had remained unnoticed in the scholarly literature about Bali, until the sudden disruption of the whole system, triggered by the rapid introduction of new agrocultural systems through the "Green Revolution" [173].

Development agencies, not aware of the role and complexity of the ancient agro-ecological systems had blamed the resistance of the farmers (to adopt the new agro-systems) on conservative religious ignorance. One statement made on an occasion by an agro-specialist was: *'These people need a hydrologist, not a priest!'* [173].

Stephen Lansing used cultural and historical analysis, supported by numerical simulation, to understand the complexity of the interdependent variables and feedback loops of human agency and the natural environment [153, 175]. The coordinating role of the temples in irrigation and harvest planning, was demonstrated in a computer simulation [175].

At last, evidence from the study of Lansing convinced donors and experts, including the Asian Development Bank, of the importance of the local knowledge and the effectivity of the ritual technology of the subaks [173]. The old wisdom, which had not yet being destroyed, could be reactivated. The subaks restored their cropping calendars and coordination schemes through the water temple networks. The rice production was restored and pest outbreaks were contained. Unfortunately, not all modern agriculture measures were abolished, and chemical fertilizers, introduced during the Green Revolution, continued to pollute the water systems for a long time [176].

This case of the subaks in Bali illustrates how interventions, based on linear innovation methods, technology transfer, and assumptions about the superiority of 'modern' technology with respect to the 'downstream, traditional, indigenous', often fail to see

local agency, community-based, collaborative knowledge production and the embeddedness of culture and meaning in everyday technologies.

10.3.2 *Farmer innovation in the Sahel*

Another example of large-scale local innovation within a social system, is the case of Regreening in the Sahel. The context of regreening is a social/ecological system, in which local actors operate, driven by the need to improve their livelihoods [249]. Without a centrally managed intervention, localized groups communicate with each other, share knowledge, and strive to solve local problems through local innovation (e.g. [251, 290, 202].) Innovations here are not high-tech, but simple traditional practices, that are reinvented and diffused within the social networks of the communities. The reason for adoption of local innovations such as stone bunds and zaï, are that these innovations solve a real problem, while being easy to implement, manual and inexpensive [155, 252]. The increase of on-farm trees is slow, as it takes a few years to have large trees [258, 257], but impacts are visible, and the innovation propagates steadily through the communities [249, 250, 252, 327].

In many rural regions of Africa, farmer-innovations, cross-learning and joint experimentation have been identified, and have been shown to be wide-spread [251, 305]. These examples of indigenous experimentation and knowledge are practiced by young and old, poor and wealthy, men and women farmers [221]. The operational goal of innovators is to improve farming, increase production, and create more resilience for families and communities [109]. Many farmers are open to share innovations. The status of farmer-innovator creates esteem in the community [303]. Innovation is community-based and emerges from collaboration through social networks and joint learning [211].

10.4 INNOVATION, KNOWLEDGE, AND SOCIAL NETWORKS

In a world full of ideas, technologies are seldom the work of one single heroic inventor. Many studies have shown how it is not the scientist or engineer, but the user, who invents a product [251, 320, 308]. In the example of Regreening in the Sahel, farmer-innovators experiment with certain techniques which are adapted and adopted by others in his/her local community [251, 133].

The emergence of innovations depends on resources that are accidentally available, whereas users give meaning to the innovation in their social practice [195, 57]. Tuomi defines innovation as something that generates and facilitates change in social practice ([308], pag 11).

Innovation does not emerge in isolation. It takes place in groups, teams or communities[8], [213, 284, 251, 308, 263], in so-called innovation networks or knowledge networks

8 We use the term 'community' here for a socially integrated group.

[308, 198]. As knowledge networks are a special type of social networks in which actors exchange knowledge, we will take a look at the definitions of these concepts in literature.

10.4.1 *Knowledge networks*

We define *knowledge* as the body of data and information that people bring to bear to practical use in action, in order to carry out tasks and create new information [284]. According to this definition knowledge is not universal, but domain-specific, only understandable in relationship to other knowledge concepts [182].

Knowledge networks can be small or big: organizations with only a few agents, up to global size as e.g. the World Wide Web [198, 66]. Knowledge in a network is exchanged or diffused, as to increase the level of knowledge among all agents. In some cases, collective knowledge can remain in certain nodes, leaving agents possess relatively unique, non-redundant knowledge. The latter configuration will enable a network to accomplish work collectively, through division of tasks [198]. Knowledge networks are dynamic in terms of actors and links: people join or leave a knowledge network on the basis of interests, resources, and commitments [198].

10.4.2 *Innovation networks*

Tuomi studied a special type of knowledge networks, i.e. innovation networks. These are social networks where knowledge is exchanged amongst its members who are driven by a purpose, a common goal to solve a problem [308]. The innovation networks described by Tuomi are not hierarchically structured, and not confined to a single organization. Knowledge creation in these networks is not a meta-process of obtaining 'information about information' [284], for the sake of curiosity, but purpose-driven, to bring knowledge into practice.

Typical examples of knowledge networks are global communities of ICT developers that organize themselves around an open-source project such as Wikipedia, open source learning environment Moodle, or open-source operating system Linux. What makes these networks interesting examples, is the fact that they exist in cyber-space, so they are easy to observe, and they are a new phenomenon, as they use the Web as their communication platform.

The development of Linux as innovation network was subject of a detailed case study by Illka Tuomi. The development of this system is not driven by economic motives and is done by voluntarily participation of developers from all over the world, who devote their free time to it [308]. As can be seen in the Linux community, this knowledge network has a core team or even a core community, which can be described as the locus of innovation. It is here where the idea initiated. The core team acts as the gatekeeper of the core technology, but they do not exert direct control over the innovation process

[308]. There is a large periphery of developers who are concerned with the less vital or more peripheral parts of the system. The periphery itself is divided in many smaller sub-communities.

Innovation networks as the Linux community are not hierarchically organized, as in real organizations [308]. Yet, there is an (informal) internal social control system, that emerged spontaneously from the communication structures in the network, that prevents development of the system to become unmanageable. To keep this complex socio-technical system alive, despite the great number of collaborators, the system's design has to be modular, so that each sub-community can work on a distinct part, without destabilizing the whole system or disturbing the work of others. Without a predefined masterplan, Linux continues to expand and improve itself by the constant work of developers all over the world, who communicate, experiment and share knowledge in many online forums, gradually increasing the total amount of knowledge about the technology itself and about its development process [308].

Apart from the special characteristics of an open-source online development community (working globally, using the Web as platform, developing at high speed), the overall process of experimentation, knowledge sharing and self-organization is not restricted to high-tech environments only. There are various case studies of community innovation in e.g. low-tech rural Africa, where experimentation takes place, ideas are exchanged, adaptation is done, improvement of the ideas or artefacts, within the communities, and ideas from outside communities are fed-back into the innovations, and social coordination is done [251, 69, 202]. The importance of partnerships, cross-learning and re-invention are shown in many studies [263, 314, 202].

In the adaptive approach people from different backgrounds collaborate to achieve a common goal. The community consists of ICT developers and illiterate farmers, local extension workers, sustainable management experts, requirement engineers, information analysts, local radio journalists. Co-creation workshops are the loci of innovation. Here the generation of ideas, the modelling of information, construction of prototypes, the exchange of knowledge and creation of knowledge take place.

The community is driven by a joint objective to improve a situation or solve a real-world problem, expressed by people, through design and construction of a useful technology. The knowledge to do this is initially not available in the team, and has to emerge from the exchange of knowledge between different team members, from experimentation and social learning during the process. This is an iterative process with many short cycles. Physical proximity is important as this speeds up the innovation process and motivates the participants to find the best solutions. Communication cycles are therefore short. There are different experts and roles in the community. There is a core team who loosely manages and keeps the process alive, as the larger community acts as a self-organizing network, without a hierarchical structure.

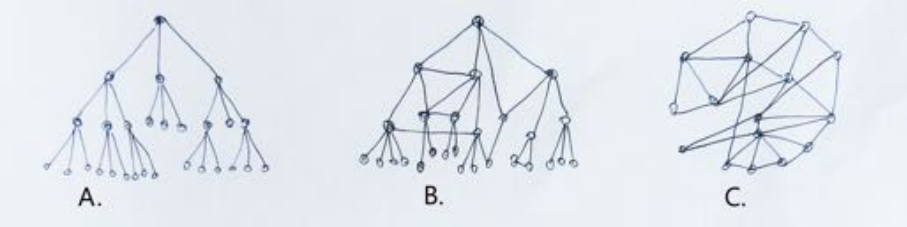

Figure 72: Model of three types of organization: A. hierarchical structure: low complexity B. hierarchical with some cross-links: intermediate complexity C. networks structure: high complexity. Adapted after Yaneer Bar-Yam 2004, *Making Things Work: Solving Complex Problems in a Complex World*. Knowledge Press, p.66 [15].

10.4.3 *Problem-solving capabilities of innovation networks*

According to complexity researcher Yaneer Bar-Yam, an organization (or a knowledge network) is only able to complete a complex task, if the level of complexity of that organization equals the complexity of the task. To measure a difficult concept as 'complexity', Bar-Yam uses the following heuristic: complexity can be quantified as the number of words which are needed to describe a certain concept. The more words are needed, the more complexity [15].

Using this rule of thumb Bar-Yam estimates that one would need 10 DVD's of data in words to describe the tasks of a CEO of an organization on one single day [15]. That seems much, but obviously the amount of complexity increases with the size of a knowledge network in which all actors exchange knowledge, with the goal to solve a technological/scientific problem.

In hierarchically organized organizations, see Figure 72 A, the information flows are only vertical. The complexity which can be tackled is theoretically that of one person only. In practice, organizations are not strictly hierarchical, but hybrid like Figure 72 B. In Figure 72 C a fully networked organization is shown. There are many more interactions. This type of organization structure is much more complex, and can tackle a much higher degree of complexity.

This model, shown from a complex system approach, supports the idea that innovation networks, where more people participate and more knowledge is exchanged, have a higher capacity to innovate and find better solutions than in the case of linear innovation, when knowledge production is considered the task of a small group of developers only.

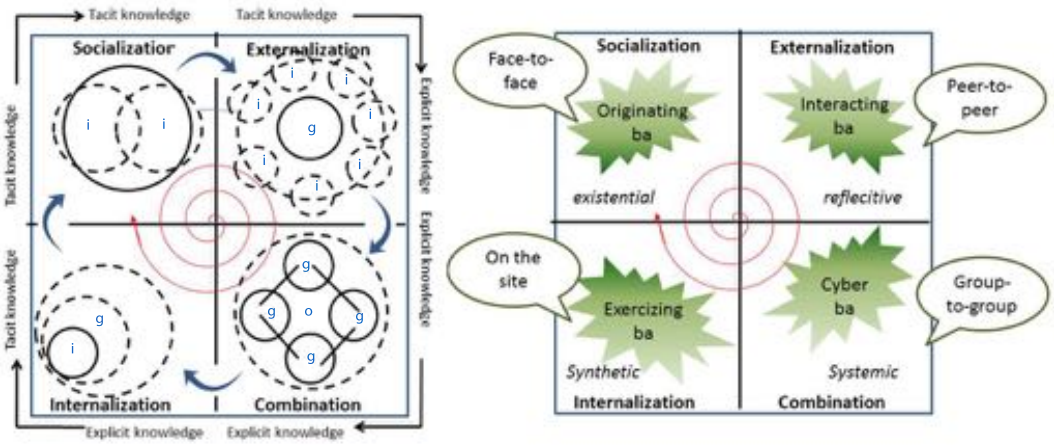

Figure 73: For each type of knowledge exchange, different ways of communication are applied and this occurs in different (physical, virtual) spaces of innovation (left); The four characteristic of Ba (right). Reprinted from: Ikujiro Nonaka and Noboru Konno. "The concept of Ba: Building a foundation for knowledge creation" *California Management Review 40(3): 40*, p.43 and 46, 1998 [213].

10.5 SOCIAL LEARNING

As discussed above, knowledge exchange is important for innovation. In the case that innovation teams consist of people with similar backgrounds, expertises, culture and language, knowledge exchange is easier to achieve than in very heterogeneous groups.

But since heterogeneity is the common situation in an 'innovation for development' setting, the process of knowledge exchange has to be well organized, and effort must be put into this aspect. This is the *social learning* aspect of innovation.

According to theories about knowledge and social learning, knowledge can be either tacit or explicit [213, 14]. Tacit knowledge is informal and intuitive, residing in people's heads, sometimes even without being aware. People may very well know how to bake a cake, drive a car or play the second horn concerto of Mozart, but they often find it difficult to explain how they actually perform these tasks. Tacit knowledge can be technical – related to skills, know how and practice experience – or cognitive – related to beliefs, values, intuitions and mental models [213]. Depending on the nature of knowledge exchange (tacit or explicit) there are different modes of doing this.

Nonaka proposed a framework[9] for knowledge exchange: from tacit to tacit, from tacit to explicit, from explicit to explicit, and from explicit to tacit [213]. For each type of knowledge exchange, different ways of communication are applied, as conceptualized in Figure 73. The (physical, virtual) proximity (space) in which social learning

9 The SECI (Socialization, Externalization, Internalization, Combination) conceptual framework of social learning, by Nonaka (1998) [213]

occurs is important for exchange of tacit knowledge. In our case study this is the physical location of the workshop, in the region where the users live. Explicit knowledge (from explicit to explicit) is easier to transfer and can be done via e.g. email, websites, written documentation, film, audio. The space where innovation occurs is very important for knowledge exchange. Nonaka refers to this (physical, virtual) meeting space of innovation as "ba", a concept from the Japanese epistemological tradition, [213].

10.6 ICT4D AS A KNOWLEDGE-EXCHANGING INNOVATION NETWORK

During our field work in West Africa, elicitation of information and knowledge of the users was part of the requirements analysis. A number of farmers – domain experts in their work, farming or pasturalism in their own environment – who participate in the co-creation workshops are illiterate. Their knowledge has never been written down and can therefore be considered tacit. During a workshop we organized in April 2014 in Ouahigouya, Burkina Faso, Ousséni Zoromé was one of the participants. He said in Mooré language: *"The farmer-innovator has the knowledge and the know-how, and he wants to share this with his community"*.

10.6.1 *Socialization during field visits and workshops*

The first technique used to obtain the tacit knowledge from the farmers is socialization. This is the transfer of tacit knowledge from one person to another, by observing, being together in the same space, working together. This was organized through field visits to rural communities. Walking together in the fields and observing users in their own working context provides tacit information to the developers team. During roadshows and workshops there are frequent field visits to several farming sites, or to local radio stations or small factories. This gives the developers' team knowledge of the local context. Developers' teams are often 5 – 8 people. These recurring field experiences create a shared group memory and understanding of the (new, unfamiliar) local context, for the developers' team. This type of social learning (tacit to tacit) is called socialization [213, 284]. Figure 74 shows how socialization is done during field visits with a group of ICT developers and farmers.

10.6.2 *Externalization through writing, modeling, structuring the knowledge*

The second step in the elicitation of local knowledge is to capture tacit knowledge from the users and make it explicit. Photos, video images and recorded audio help to capture the information. Use case and requirement analysis techniques provide a structured approach to capture the requirements of a technological solution, and make them explicit [181, 185].

Figure 74: Field visits are organized to exchange knowledge that is difficult to understand, without seeing the context.

Capturing local knowledge involves focus group discussions, interviews, group assignments, groups presentation, semi-structured questionnaires, and long dialogues. It is done with groups of users and other stakeholders, usually business partners. Since there are different languages, there are always translators, from local language, (Mooré, Bambara, Bomu) depending on the region, to French (in Burkina Faso, Mali) or English (in Ghana), sometimes even to Dutch. An example of this type of knowledge production (a requirements analysis workshop) is shown in Figure 75.

The tacit knowledge obtained by the developers' team can be seen as a form of context knowledge, this is tacit, and difficult to capture in text. However, this knowledge is crucial for the technological development. All core team members who are involved in the co-design, must have this field experience. This is an essential aspect of the approach to ICT4D.

The next phase consists of needs assessment and the collection of key ideas. This involves mutual learning, as the local users must become familiar with technology and ICT. This is done by demos and users testing certain prototypes, to give them a look and feel of an application. These techniques also involve tacit knowledge and are part of the socialization process of social learning.

From these social learning sessions, ideas are generated, by the users. "We want a system that gives us information on the weather, accessible on our phones." We would like to have a way to diagnose diseases of our cattle. We would like to have an alert when it will storm." All these ideas are collected and structured formally into a use-case format. This type of capturing and structuring the ideas is referred to, in the SECI model, as "externalizing" (see Figure 75).

Having collected a list of ideas and made a selection which one to further develop, the exact requirements have to be sought. This is again a process of information elici-

Figure 75: A group of farmers-innovators from the Zondoma and Yatenga regions, Burkina Faso, during a requirements engineering workshop, June 2016, formulating their information needs.

tation. This is often done using informal scenarios, story boards or conceptual models. There are several iterations, to make sure users and developers understand the design of a technological solution and all its requirements.

All the information collected about the requirements is modeled using formal and informal, conceptual methods. Conceptual modelling stems from the tradition of ontology engineering, requirements engineering, design science [2]. Conceptual modelling comprises the activity of formally defining aspects of the physical and social world around us for the purpose of understanding and communication [205]. Conceptual models, either formal or informal, are powerful communication tools, as they can clarify certain complex processes or information that is difficult to explain in words.

Formal models are designed as UML diagrams, and conceptualize certain aspects of the solution or workflow. Together with questionnaires, they are used to store all information in a structured way. Formal methods are often used for further development or technical specifications for the ICT-developers and software engineers. Informal models such as story boards, scenarios, narratives, films, are useful for communication between developers and users, to make sure that there is a shared understanding of the technology and its design and requirements. This form of social learning is called externalizing [213]. It is a form of converting tacit into explicit knowledge.

10.6.3 *Combining various sources of knowledge*

The actual design of a technological solution requires a combination of different types of knowledge. This is also a crucial aspect of ICTD and innovation for development, as it provides the combination of local and non-local knowledge, i.e. technical ICT knowl-

Figure 76: A group of students and supervisor at VU, building systems for farmers in Ghana and Mali, during the ICT4D course in May 2014.

edge and user requirements, which reflect the work, tasks and context of the local users. It entails the act of integrating, analyzing, disseminating, reorganizing explicit knowledge.

The new knowledge is a result of recombination of existing knowledge (e.g. how to design ICT systems, how to analyze and model information, how to plan cropping calendars in rural Mali, how to diagnose chicken disease, how to prototype and build a voice application and deploy it on a voice-based platform).

An example of a form of recombination of knowledge (explicit-explicit) is shown in Figure 76. Master students in the ICT4D course at VU, working on use cases that were collected and elaborated by the W4RA team together with farmers in Ghana and Mali.

In the case of RadioMarché the combination of knowledge on speech technologies, knowledge on database and interface programming, knowledge on the seasonal availability of non-timber forest products in Mali and knowledge of Bambara and Bomu languages made it possible to build the system. Since there is no person in this world with this specific combination of expertises, the construction of RadioMarché is a unique example of a combination of local and non-local knowledge, through collaborative innovation. This type of knowledge transfer, explicit to explicit, is called, according to Nonaka's SECI model: "combination" [213].

10.6.4 *Internalizing the new knowledge*

As the last of the four, there is the internalization of knowledge, the act of learning, and embodying explicit knowledge into one's mind through action and practice and through a process of meaning creation. This is another aspect of knowledge exchange

in innovation, as it relates to group identity, and provides meaning to the technological innovation. Internalizing can be described as a way of converting explicit knowledge into "tacit". This is the social, non-materialistic aspect of the technological development within an innovation network. This will be discussed in the next section.

10.7 INNOVATION, MEANING AND CULTURE

The entanglement of technological innovation with culture and symbolic meaning has been shown in various studies (e.g. [57, 173, 38, 229, 227, 294]).

Communication scientist Anita Chan studied this for popular cultures in Peru. Chan focuses on the rituals, ceremonies and other meaningful expressions that surround communities of techno-innovative youngsters and hackers in Peru who are creating alternative learning and research sites, as they say 'to bridge technology, art, and society' [57].

Chan describes how digital communities of technicians and teachers jointly embraced the OLPC program, which by 2008 was massively rolled out at primary schools by the Peruvian government, without any support or implementation plan. Chan shows how local community-based initiatives took off, created content and translated the existing content of the XO laptop of OLPC into the local indigenous languages Quechua and Aymara. She describes how face to face meetings of local ICT developer teams took place, and local ceremonies were held, with prayers to local spirits, as meaningful expressions of the uncertainties surrounding the ICT deployments and other technological developments. Chan points at the untapped and unexplored innovation capacity of the peripheries – sites in developing regions – with respect to the incumbent, elite design centers [57]. Quoting Anita Chan:

> *"... gray markets of digitized local music and pirated films fill multi-story buildings, and street markets of used, recycled, and reassembled computer parts and people meet at local Internet cafés. Such technological hacks and local improvisations are an everyday part of the periphery's technology landscape [57]."*

Through the images of vibrant contemporary Peruvian socio-technical culture, in what Chan describes as *networking peripheries*, she shows the role of community and their cultural, meaningful expression in the use of technology in daily practice and its embeddedness in local context. Chan also shows how, in these peripheries, technologies are appropriated by local communities and reinvented and embedded into local culture [57].

Inge Brinkman and others studied the social and cultural meaning of mobile phone in the streets of Khartoum, Sudan, and made this observation: *"The function of status marker related to the mobile phone has shifted to middle-class residents and even to those on low incomes. They save up to buy the latest model, decorate it with lights and other accessories, equip it with fancy ring tones and wear their phone conspicuously on their belt."* [38].

Another study on mobile phone use in Africa, by Julia Pfaff, also demonstrates 'meaning' which is attributed to a technological device: *"It is evident that the mobile phone is much more than just a tool for calling, text messaging, music, photos and phone numbers. It is the device itself as well as its attributes that play a role in processes of individual expression and identification. The relationship of the Zanzibari woman to the phone and the phone as 'imagined adaptability', 'temporary enjoyment' and 'bongo life' point out how the mobile phone works to demonstrate the importance, financial situation, style and 'trendiness' of its user "*[229].

Lotte Pelckmans did extensive field research on the use of mobiles in Mali. She describes the variety of cultural codes that have emerged, regarding the use of the mobile phone:

> *"A Malian phone credit seller explained that flashing [letting the recipients phone ring once or twice without making a call] could be compared to tapping someone's shoulder or winking at them as it is a means of confirming and/or reminding the other person that you are friends (qu'on est ensemble) [...] In Mali when someone flashes someone who is clearly better off, more often than not the flash is no longer a metaphorical 'digital blink' but should be interpreted as a request to phone back. The one considered to have money at his disposal is thus put in the position of the 'credit caretaker'. [..] Some flashers are so persistent that new strategies to avoid them have emerged: taking several numbers with different companies, changing one's phone number regularly or giving a wrong number."* [227]

In our case studies in West Africa rituals, social practices and symbols played an important role in the formation of shared experiences in the multi-cultural team. This gave meaning to the partnership and to the technological innovations that were built. This is expressed by the use of logos, the names of ICT services in local language, given by the local partners: Foroba Blon in Bambara language (the space where one can speak out), Tabale (the king's drum in Mali), Raas Kibaya in Mooré language (market information). Visits to village chiefs, opening ceremonies of workshops, group pictures, T-shirts with project logo, are all expressions of a self-created group culture, that can be seen as the social, non-materialistic aspect of the technological development within an innovation network.

10.8 SUMMARY

In this chapter we have taken networked complexity as a theoretical lens to observe the dynamic processes in a given development context, and to explain how a networked approach to ICT4D makes it capable of coping with this complexity. Various examples of innovations show how the adoption of technologies fundamentally deals with innovation and its diffusion. This occurs in complex, nonlinear processes of change, in which knowledge and information propagate through social networks and contextual

factors come into play. A networked approach means two-way knowledge sharing = *collaboration* between various stakeholders, including ICT developers and users. This underpins the need for an *adaptive* process of socio-technical innovation (to fit the variety of contextual requirements), *collaborative* (to encompass as many viewpoints and knowledge domains (academic/non-academic) as possible on the subject and context), and *iterative* (because of learning cycles).

11

THE VALUE OF COLLABORATION

"Be Collaborative", the ninth Principle for Digital Development [323], is not an issue to be solved at the technocratic level only. It requires a debate at the policy level. In this chapter we want to reflect on what the ICT4D researcher can do to include a critical, normative element and engage in the Development debate. We discuss how the ICT4D 3.0 framework relates to policy issues and debates, and compare it to other frameworks.

11.1 THE VALUES AND INTERESTS DIMENSION IN ICT4D

As discussed in Chapter 1, "Be Collaborative" is the imperative of the community of international development donors and multilateral organizations to the community of ICT4D practitioners [323]. Yet, is this something to be solved at the operational level only?

To clarify this question, I take a look at e-Choupal, a development project in rural India, to "serve the world's poor, profitably" [236, 237]. As one of the largest ICT for rural development projects in India, it seeks to combine poverty alleviation with profit for the private sector. e-Choupal is an initiative of ITC Limited, one of India's leading agriculture firms. The project received international awards for furthering the Millennium Development Goals and contributing to economic development in rural India[1].

The e-Choupal project is prototypical for the free-market ideology, which, according to the advocates of appropriate market interventions, can help private businesses make profits, while achieving poverty alleviation at the same time: (cf. *"as the poor get richer, they buy more of the goods and services that industrialized countries produce, ensuring a benefit to all from poverty reduction"* [140]). However, detailed field evaluations in Utter Pradesh, India by independent researchers revealed that poor farmers had been disadvantaged by the intervention. A perceived increase of social and economic inequalities was attributed by local farmers to e-Choupal [318].

e-Choupal shows how ICT4D can lead to diverging interests between the private sector and the supposed "beneficiaries". One of the prominents in the academic field of poverty and development, Nobel-prize winner and economist Amartya Sen, (often quoted in ICT4D literature e.g. [167, 115]), envisages a world of *"reasoned social progress"* [289] (p.279), in which well-informed individuals contribute to policies that promote a just and prosperous society in the context of free speech and free markets [277]. A critical question here, is whether "the poor" are well-informed, if the information

1 Source: http://tinyurl.com/empowering-farmers-echoupal (accessed 31-07-2019)

provided to them is relevant and unbiased, whether it can be critiqued and verified and it will provide them with capabilities.

Decision-making in ICT4D, according to democratic values that are loudly claimed by our modern Global North society needs to be inclusive and involve all stakeholders – also the voices of the people who are often referred to as the "bottom of the pyramid" [237].

Given that there are many such projects as e-Choupal in which information, technologies and actions can – tacitly or explicitly – constitute structures of dominance [90, 125, 299], and issues related to poverty, livelihoods, interests and power are being affected by international development policy, is there a role for a critical ICT4D researcher/reflective practitioner in addressing these core issues?

11.2 ALTERNATIVE METHODS OF KNOWLEDGE PRODUCTION

In his recent book *"Reclaiming ICT4D"* [310] Tim Unwin (2017) states: *"[..] we should not be working for the poor, but rather with the poor if they are truly to be empowered. Far too many ICT4D initiatives have been designed for the poor, often with good intentions, but they fail because they have insufficiently involved the poor in their design and implementation."* A point to note here is that traditional paradigms of science, e.g. empirical social research on innovation and technology, or quantitative hypothetico-deductive dependent/independent variable research [4] do not allow the researcher to take a critical position in value-laden discussions [218, 108]. To do so, one has to resort to different "ways of knowing", that make a related distinction: knowing-through-thinking vs. knowing-through-doing [246].

The classic concept of *phronesis*, described by Aristoteles is a knowledge category and an intellectual virtue that includes practical reason and prudence, and is therefore suited for research in ICT4D. It is a critical and discursive research approach in contrast to the two well-known knowledge concepts: *episteme* (analytical knowledge, universal truth) and *techne* (art, instrumental skill, technical know-how) [10]. Phronesis is encountered in, for example, technology and engineering [326], web science [4], (participatory) action research [93, 95, 246] and social sciences [104, 279].

A second concept for reflection is *agora* [217, 4]. *Agora* can be understood as society or real world social context, i.e. the space where research activities are situated and debated. *Agora* reflects the presence of interacting actors and co-creation in this space of knowledge creation: the local context, the field-based collaborative research. In our research, collaboration as a goal-constructing mechanism, and as sociotechnical innovation, is taking place in the *agora*, i.e. outside the traditional loci of academic scientific research. This holds e.g. the notion of transdisciplinarity – in the sense of collaboration between academics and non-academics – because of the necessity to engage multiple perspectives from various knowledge domains to tackle complex real world problems [218, 179].

Examples from purpose-oriented, practical, field-oriented, (action) research, can be found in disciplines and research communities over the past decades (e.g. [54, 49, 286, 287, 94, 95, 107, 179, 34, 251, 252, 202, 70]). An example is Chambers' critical call in 1983, for putting the farmer first in rural development [47] up to his more recent studies [50, 52, 51]. This actionable, practically oriented approach shows the need for value-driven research, inclusiveness, reversed (grassroots, south-north) perspectives, and imagination. Chambers introduced the user-centered "people paradigm", in contrast to the, what he calls "things paradigm", which describes the interventionist approaches to rural development, based on transfer of (agro-) technologies, expert-based knowledge transfer, and outsiders biases [50]. Chambers' work has had much influence in stirring up the development debate, and has influenced the Development discourse [286].

An argument to bring critical analysis into ICT4D research – from a theoretical point of view – is brought forward by Tim Unwin in the recent book "Reclaiming ICT4D", [310]. Unwin proposes a framework for critical ICT4D research, based on the work of the German philosopher Jürgen Habermas [132] and the Frankfurt School of Critical Theorists. An important aspect of Habermas' critical theory is normative science ('what should be'), in contrast to the more common positivist ('what is') approaches. Normative science gives a direction and wants to make this world a better place [310]. Normative science holds a responsibility to take the best decision, based on prudent practical judgement [159].

What these studies have in common – despite the different traditions from which they emanate and the different approaches they use – is reflection and critical thinking, the idea of society, community, reciprocity between science and society, and the acknowledgement of the importance of context. How are these value-laden aspects of policy and practice addressed in various ICT4D studies?

11.3 VALUES AND INTERESTS IN ICT4D RESEARCH

There seems to be a dynamic tension, in the growing field of ICT4D policy research, between those who focus on business and economic development and those who focus on empowerment and community development, the two most salient domains in this field [117]. Since business and economic development are part of the incumbent political ideology, while empowerment and community development are desired endpoints only, this tension can be seen as a choice between the objective, value-free, positivist research, and normative research: "as it should be". Many studies that include a normative element stay at a rather abstract level. Do these studies include an empirically grounded critical aspect? What values do they espouse and what implications do they have for practice? Moreover, is this debate informed by context-embedded field research or goal-constructing collaboration? In search of an answer, we briefly discuss a

number of ICT4D-related studies for an inclination towards value-driven research and critical engagement.

A review of key ICT4D academic research shows that value-driven research in ICT4D is often seen as problematic. In disciplines such as computer science the focus has been traditionally on the "advanced" western, connected world. It takes the Global North context for granted (as if it were a universal context), and more strongly, views this as the blueprint for the Global South. Field-based ICT4D research, aimed at downscaling and decentralization under low resource conditions, is not naturally recognized academically as an interesting research direction.

In certain research paradigms, solving real world problems is considered unscientific (e.g. [39, 147]). In human computer interaction research for development (HCI4D), a discipline related to computer science, and embedded in global development, some researchers complain that they are distracted from their scientific work, as they are asked to engage in tasks that have more to do with helping the poor than in writing scientific papers [147]. Some research communities, especially in the social sciences prefer to speak about ICTD, removing the purposeful "4" (for), to avoid the impression that this research aims at "helping people" [44, 306].

Another example is a recent policy-informing research paper titled: "ICT4D 2016: New Priorities for ICT4D Policy, Practice and WSIS in a Post-2015 World?" [142]. This paper proposes the following technologies for ICT4D: *"near-ubiquity of mobile, spread of broadband, more big/open/real-time data, use of field sensors and embedded computing, more social media, more crowd-sourcing models, more cloud, more smartphones, and 3D printing"* [142]. This is the typical type of technology transfer from the Global North to developing countries. Context is not taken into account. A debate about development goals and objectives in a dialogue with the actual users, is not considered in this paper. This illustrates how interventionism in ICT4D is taken for granted in policy-oriented research.

In a study by Roger Harris (2016), titled "How ICT4D fails the poor", is described how 272 ICT4D researchers were inquired about the impact of their ICT4D research (not taking into consideration academic impact i.e. citations, but only real world impact) [136]. Harris shows in this study how ICT4D researchers are more concerned with citation indexes than reaching and influencing policy. Harris argues that ICT4D research "fails the poor", because it fails to reach the (evidently Global North) policy makers and practical experts – readers outside the academic community [136].

Harris' study shows how the majority of ICT4D studies are not intrinsically policy-oriented. Some are policy oriented but do not acknowledge the reality in the field. Desk studies (often from MIS, the Management Information Systems discipline) lack the necessary field experience to generate a well-informed debate. Apparently, many ICT4D researchers do not participate at all in the development debate, and do not display any concern about purpose, interests and values [136].

Surprisingly, Harris' study not only shows the disengagement of the academic community to contribute to the ICT4D debate at the policy level, it also shows, indirectly by his own research, how the role of beneficiaries as stakeholders in the ICT4D process is absent in ICT4D (desk) research. Harris himself does not mention the role of beneficiaries as stakeholders of ICT4D. The recommendations Harris makes towards the academic ICT4D community is that more efforts are needed towards influencing policy. The arguments given by Harris why this is important speak for themselves: (i) to continue receiving funding; (ii) to realize their potential for influence on international development policy and practices and (iii) because it is the right thing to do [136].

In another policy-oriented study from 2008, the idea of "ICT4D 2.0" is introduced [140]. It presents itself as an alternative to widespread observed failures and lack of sustainability of the large class of ICT4D telecentre projects and off-the-shelf solutions, which he refers to as the first generation: ICT4D 1.0. ICT4D 2.0 is presented as a new generation of ICT4D approaches, which are said to be characterized by new technologies, new approaches to innovation, new intellectual integration and even a "new view of the world's poor" [140].

A close read of this essay [140] gives a different impression. ICT4D 2.0 does not take any distance from the well-known one-sided transfer of technologies from the Global North. Adaptive, iterative or contextualized methods are not mentioned in this paper. Despite mentioning "pro-poor, para-poor, per-poor innovation", the paper does not give any evidence whatsoever of user-centered methods or "participation" by end-users. When it describes "intellectual integration in ICT4D 2.0", this paper proposes to bring together three so-called "ICT4D champions" which happen to be researchers from (i) computer science, (ii) information systems and (iii) development studies, to let the champions jointly solve ICT4D issues [140]. Here again, the stakeholders from the Global South – the "poor and unconnected people" – are absent in the innovation process and in the debate about issues that concern their livelihoods.

As this paper demonstrates, in ICT4D 2.0 diverse considerations from the Global South — which significantly differ from those of the Global North – are not mentioned or taken into account. The importance of collaborative sociotechnical innovation, of how to deal with complexity and dynamic contexts – all crucial elements in sociotechnical innovation processes – are not mentioned in [140].

When it comes to values and interests, the essay mentions: "ICT4D offers new opportunities for informatics professionals and new markets for ICT vendors" [140]. The claim that ICT4D 2.0 will benefit "the world's poor, those who suffer from the blot on the global conscience" is not substantiated with evidence, but echoes the underlying assumptions and ensuing limitations of the interventionist approach.

Another essay [140] considers how modern ICTs might benefit the poor. Concerning low-literacy, it writes (p. 28): *"Equating the poor in developing countries with illiteracy is a common mistake. Adult literacy, even in the world's poorest countries, is still greater than*

50 percent, and two-thirds of 15- to 24-year olds are literate. Effectively, every community will have at least some literate members who can act as infomediaries (...)".

The general statement as quoted above carries practical implications, in this case by suggesting that illiteracy is not an issue (anymore) for ICT4D development projects that supposedly are to the benefit of the poor. It is perhaps unavoidable that ICT4D desk research at-a-distance relies for its argument on simple statistics such as a global average. But it does introduce significant external biases that should not go unchecked. This simple statistical average argument overlooks a lot of on-the-ground key facts that basically relate to the underlying distributions. Here, for example, (i) there is a big difference in literacy between urban and rural areas, and most of the poor in Africa live in rural agricultural regions; (ii) it ignores important gendered differences and issues as there is a clear literacy difference between men and women. In addition, the suggestion that the few literates in rural communities and villages will act as infomediaries contains a lot of unchecked wishful thinking, and ignores the many subtleties, known from practical experience as well as the scholarly literature, concerning the social networks that are involved in spreading sociotechnical innovations [263, 202]. So, it is also a clear case of (mis-)use of a simple statistic [151].

The [140] assertion as a generalized statement is therefore unjustified, as it ignores the strongly *contextual* aspects of ICT4D development projects. The way to find out whether such statements and claims are warranted, is to investigate them in the field. This illustrates the important contribution of practical case-oriented field-research, because this provides field evidence to inform policy and bridge the (physical, conceptual, cultural) distance to the end-user at the grassroots level.

An example of a study that accepts the reality of contemporary development policy "as-is" is an essay by Burell and Toyama (2009), titled: 'What constitutes good ICTD research?' [44]. This essay consists of a discussion about the tension between qualitative and quantitative research methodologies and their respective communities. About the purpose of development the authors accept that there are different notions of development: "... there are additional tensions between top-down versus bottom-up approaches, between providing welfare and promoting agency, and between paternalism and partnership. *'For ICTD, what we'd like to propose is an acceptance that all of these viewpoints will and should continue to coexist within the community'* [44].

In sum, my analysis above supports the views of Harris [136] and of Burell & Toyama [44], that ICT4D academic research is only marginally addressing the core issues in the Development debate, that concern interests and values related to ICT4D.

11.4 COLLABORATIVE ICT4D AND POLICY FRAMEWORKS

As discussed, to bring the voices from the grassroots to the level of policy, ICT4D has to include a critical and normative element and raise issues about poverty, livelihoods, in-

terests and power. This can be done, for example, by comparing and debating different policy frameworks and their underlying principles.

Policy frameworks are instruments to create a shared understanding, to guide decision-making, communicate purposes and principles. In international development they guide the formulation of programs and projects[2] and frame concepts in the Development discourse [90]. Policy frameworks have a positive (how it is; shared knowledge) and a normative aspect (how it should be; shared vision) [143] expressing political ideology. In this sense, ICT4D 3.0 can also be interpreted as a policy framework, because it has policy dimension implications. How are other frameworks for ICT4D?

I take as an example the intervention framework, discussed in Chapter 2. This framework echoes the conventional Development discourse which predominates in the institutions of development and national governments [90, 286]. This discourse is influenced by ideas from colonialism, classical economy, neoliberal thinking, contemporary management practices [91, 139, 95, 286, 50, 244].

Richard Heeks in his book "Information and communication technologies for development" (2018) [143] proposes a foundational framework for ICT4D. See Figure 77. This model shows a linear value chain which starts upstream with precursors (policy context, regulatory, institutional environment and infrastructure), and *(ICT)* 'readiness' i.e. the systemic prerequisites including hard factors (data, money, technology) and soft factors (knowledge, motivations, political support). This stage is followed by 'availability': the making available of technology, for example by bringing telecenters and cybercafés. This is followed by uptake/adoption/use and finally development impact.

Heek's model abstracts technology down to artefacts, "things" that can be transferred and deployed locally. Users and stakeholders in this model enter the stage only after decision-making has taken place. Contextual factors (called here "exogeneous factors" in Figure 77) come into play in the final stages only. The model implies that innovation can be fully planned. Outcomes and impacts will occur according to strategy and planning. User needs are not addressed by this model. Issues related to interests and power are not mentioned. Concerns about livelihoods are left out. The model in Figure 77 represents an abstract, contextless world in which technology must be or is rolled out according to plans.

The proposed framework ICT4D 3.0, as shown in Figure 78 takes a different strand. It starts from the opposite direction: not with technology or infrastructure, but from the users' needs and their desired outcomes. It moves backward, towards defining what is necessary to achieve this (see Figure 78). The first concern is to elicite local operational goals, analyse the context. By putting emphasis on involvement of local knowledge and collaborative decision-making, and by focusing on the broader context of the users (see: Chapter 4) the model safeguards the idea of inclusion (extensively discussed in Chapter 5).

2 See e.g. ADS Chapter 201, USAID Program Cycle Operational Policy https://www.usaid.gov/sites/default/files/documents/1870/201.pdf, (accessed 31-07-2019).

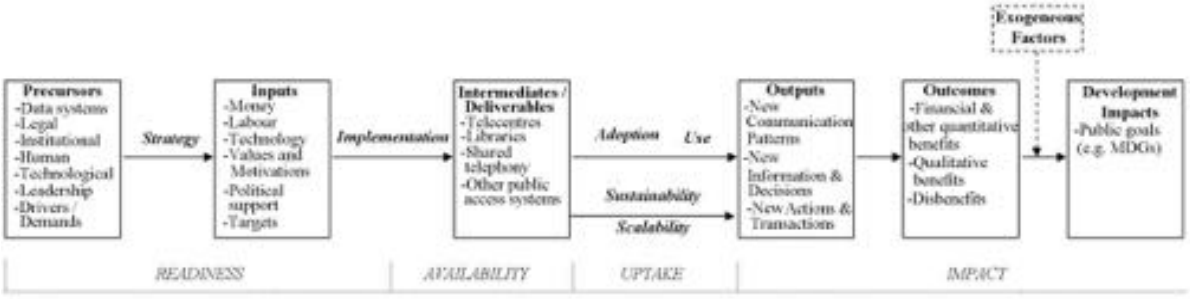

Figure 77: ICT4D Value chain. Reprinted from Richard Heeks, 2018 *Information and Communication Technologies for Development* London: Routledge [143].

Context in ICT4D 3.0 refers to local "livelihoods"[3], or more specifically *the total social, physical, cultural and economic environment(s) that directly or indirectly influence the user and his/her community in relationship to the envisaged technological solution*. By involving "context" in this broad definition, the networked, community-based aspect of ICT4D is expressed, in contrast to approaches that address the user as an individual, detached from his/her social network(s). Figure 79 shows how this is made operational.

The framework is normative and challenges the conventional thinking about technology in ICT4D policy. It informs the Development debate that there is no need for technological determinism, in which we have to accept technology "as is". In this book we point out in practice how down-scaled, networked and inexpensive alternatives are possible for ICT development, as discussed in Chapter 10.

While being critical, the framework does not embrace the idea that ICT is only "a grand contemporary strategy for the penetration and control of the Third World" [90]. Its sociotechnical approach acknowledges ICT as flexible, inexpensive and adaptive, not necessarily requiring high investments. Moreover, it bridges the gap between user-centered practical action and policy in ICT4D.

11.5 A POSITIVE AND NORMATIVE ARGUMENT FOR COLLABORATION

Given the domination of interventionist approaches and implicit power, it is important to propose alternative, collaborative frameworks. According to a normative argument ('we want ICT4D to be in the benefit of the poor and unconnected people') it is the critical researcher's responsibility – however small her contribution – to engage in the Development debate and help bring the voices of the beneficiaries/users/communities to the level where policy is being formulated.

3 For an extensive discussion of the term livelihoods, see e.g. Scoones (2009) [286, 49].

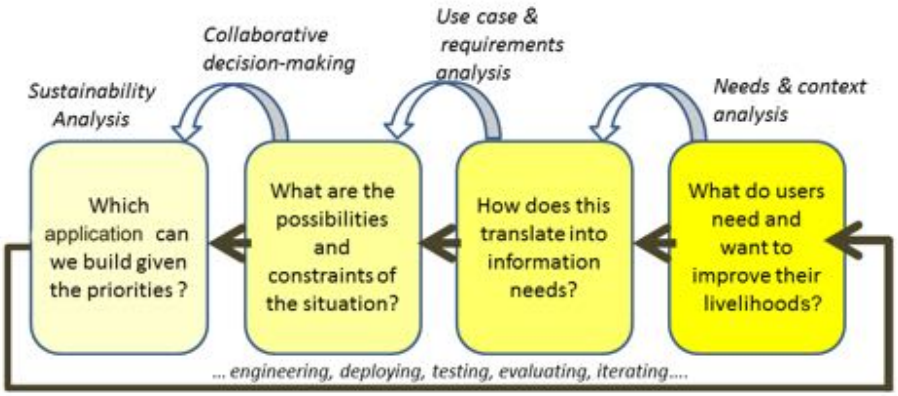

Figure 78: Alternative framework for ICT4D. It starts from the user needs and perspective, moving bottom-up. Users and context are guiding the technological design, development and deployment in this model.

Figure 79: ICT4D 3.0 as collaborative, user centered approach, that positions the users' needs at the center of the technology development process.

12

THE 10TH PRINCIPLE FOR DIGITAL DEVELOPMENT: PUTTING THE LAST FIRST

In this last chapter we revisit the questions formulated in Chapter 1, section 1.3.1: (i) "What are the underlying assumptions and ensuing limitations of the mainstream Global North approach to today's ICT4D projects, programs and policies?" and (ii) "How can we correct for these limitations of ICT4D, so as to come to a new approach that truly incorporates the diverse considerations from the Global South – which may significantly differ from those of the Global North?" The ensuing design question to (ii) is "Can we design an operational approach to developing ICT systems and services, such that it takes into consideration the complex realities of local context, and involves the envisaged users in decision-making and sociotechnical development?"

12.1 INTERVENTION OR COLLABORATION?

Regarding question (i) the underlying assumptions and ensuing limitations of the mainstream approach to today's ICT4D, as expressed in international development policy and programs, this study has demonstrated how a "linear", mechanistic notion of "intervention" lies at the root of ICT4D in international development, where "change" is thought to be (causally) brought about by an intervention. This is generally conceptualized as some measure, such as a new technology – say ICT, or Internet – or some other "improvement" that is introduced from the outside and as a result, in a deterministic way, is supposed to cause social change. This shows how the practice of ICT4D in development projects and programs is tacitly conceptualized as a linear transfer of technologies and knowledge, from the Global North to developing regions. It shows how this approach ignores the subtle and contextual realities that influence the processes of sociotechnical innovation and social change.

We have pointed out in this book how, in the linear model of innovation, the source of innovation is situated 'upstream', at the loci of the inventors, researchers, developers or manufacturers [308, 319, 320]. This condition draws a physical or conceptual (geographical, cultural) barrier between the upstream (inventor/manufacturer) and the downstream (passive customer, user, beneficiary) in the 'receiving' or developing region, and implies a one-way information flow, downstream. The linear model does not acknowledge or support a two-way interaction interface between developer and user. The information from communities of users is not used for (re-) design or further development. It does not feed the inventor with new contextualized knowledge.

In contrast, our study takes a different approach, focusing on context analysis, needs assessment, user and (local) business requirements analysis.

12.2 INNOVATION

With respect to the second question, "How can we correct for these limitations of ICT4D, so as to come to a new approach that truly incorporates the diverse considerations from the Global South – which may significantly differ from those of the Global North?" A point put forward in this book, from the perspective of innovation theory, is the interpretation of ICT4D action as a *networked* process of sociotechnical innovation. Complexity theory offers a theoretical lens to explain why ICT4D projects are inherently complex, why they easily fail, why simple recipes (such as linear intervention) do not work in most cases, and why alternative engineering and management methods (dubbed iterative, adaptive, collaborative) are needed to deal with real-world contexts. This is an alternative to the incumbent intervention models that take the introduction of ICTs in developing regions as a regular business-as-usual measure, and therefore overlook the complex nature of change.

The idea of ICT4D as innovation has implications for the operational domain. We therefore propose an operational approach to ICT4D systems and services, that (i) takes into consideration the complex realities of local context, and (ii) involves the envisaged users in decision-making and sociotechnical development. This operational framework and methodology, is dubbed ICT4D 3.0.

12.3 THE PROPOSED FRAMEWORK: ICT4D 3.0

As discussed in this book, "being connected" is important for social and economic development, even of poor regions of the world. ICTs can help users to achieve their operational goals. But how can we know what the "unconnected want"? ICT4D 3.0 is a framework and methodology for collaborative innovation that takes the users' perspective. It covers the full lifecycle of technical development and deployment and is composed from reconfigurable elements: context analysis, needs assessment, use case & requirements analysis, designing, building & evaluating, sustainability assessment.

ICT4D 3.0 is thoroughly and inherently *collaborative, adaptive and iterative*, throughout its lifecycle. It puts emphasis on (i) the composition of the interdisciplinary and multicultural team, (ii) the importance of the early upstream stages of ICT systems development, (iii) two-way knowledge exchange between developers and users.

12.3.1 *Context*

In this book we position *context analysis* as a starting and recurring activity in sociotechnical innovation. The argument here, underpinned by theory from complexity research and diffusion of innovations, is that novel technologies can only become succesfully embedded, if there is the ability to cope with the dynamics of real world contexts. To do so, ICT4D 3.0 provides a context-sensitive, multi-perspective, networked approach. Sociotechnical development takes place within a knowledge network. The *iterative* and *adaptive* aspects of ICT4D 3.0 reflect its agile, user-centered attitude, in which socialization, explicitation, combination and internalization of knowledge in a network of innovation is leveraged, in multiple learning loops.

As an example, this book presents a new method for use case and requirements in a context of high complexity: the "structured narrative method". This method captures and structures key ideas and user stories and other forms of complex unstructured information and converts it into a structured format. The method facilitates communication about requirements in a non-formal way, using narratives and storyboards, but also captures technical system specifications and represents the information through formal models. This method is appropriate for ICT4D software development projects as it bridges the worlds of users and technical developers. It covers more than just the narrow technical system. It includes business requirements and information related to the local context – topics not commonly covered in mainstream use case and requirement analysis methods (see e.g. [122, 169, 181, 296]). The structured narrative method is useful for ICT4D, but is equally useful in other software development projects, especially in dynamic (complex) contexts or in projects in which communication between various stakeholders is cumbersome, due to e.g. large differences in backgrounds or world views.

The aspect of sustainability assessment in ICT4D 3.0 is covered through a methodology that is based on yet another *networked* aspect of ICT4D, presenting it as a networked constellation of agents or actors exchanging value. This element is a structured, formal method to assess financial sustainability and feasibility of ICT services in low resource environments. Such an approach or method is still lacking in sustainability studies on ICT4D. The proposed method is easy to learn and can be used to evaluate networked value constellations in any context. It is based on the e^3*value* methodology and allows early qualitative or quantitative assessments and evaluations of potential value of the service for the complete value network. The sustainability assessment method is collaborative, based on locally collected business requirements. It is part of the process of collaborative goal construction, portfolio selection and use case and requirements analysis.

For this sustainability assessment it is important to note that (i) the exercise of business analysis should be done collaboratively, involving local users and business partners; (ii) the sustainability assessment should go hand in hand with a proper context

analysis; (iii) relevant quantitative data are needed to feed the models; the data have to be provided by local stakeholders and business partners.

12.3.2 *Collaboration*

Collaboration between developers, end-users and other stakeholders is the key element of ICT4D 3.0. Collaboration is a practical methodology, facilitating innovation and knowledge exchange. More fundamentally, ICT4D 3.0 acknowledges collaboration as a core principle of equity, inclusiveness and respect for the end-user. It holds the intention to jointly improve a real-world situation. An important implication of the collaborative approach, is that it allows end-users to define project goals and objectives. This is inherently different from projects that consist of implementations of externally designed solutions according to externally (donor-)defined goals and objectives.

Collaboration implies a multi-actor network approach where diverse viewpoints are confronted and diverse knowledge domains come together[1]. Yet, collaboration, according to the present research does not equate to the position that local users are the only contributors to this process, or that an ICT4D program should necessarily emerge from the grassroots. Collaboration in ICT4D means also: bringing in technical judgment and associated ICT knowledge and skills, as ICT professionals can do (and in the case of low-resource environments this is often from outside the community of users).

As an answer to subquestion (ii), ICT4D needs to be placed in and confronted with the critical international Development debate. If ICT4D wants to declare itself "pro-poor", "para-poor" or "per-poor" (e.g. [140, 143]), it must be capable of demonstrating how this inclusion and acknowledgement of local agency and context are to be operationalized. Validation by local users and field-based evidence are required to warrant the claims. We do so by placing ICT4D 3.0 in the tradition of various critical studies, that put the farmer first and acknowledge the importance and value of local agency, local knowledge and local innovation capacity: e.g. Chambers (1983, 1994, 2010), Reij (e.g. 2001, 2005, 2009, 2015), Scoones (2009, 2015), Fals Borda (1979, 1987, 2013), Mudhara et al. (2016) and others. [47, 56, 50, 251, 249, 250, 252, 93, 94, 95, 70, 286, 287, 202].

The endeavour to be collaborative by e.g. eliciting the voice and views of supposed beneficiaries (such as rural villagers and smallholder farmers in the Sahel in this case, often lumped into the label of the rural poor) has to take a central place in this type of ICT4D research. This is a normative standpoint, but this study in addition shows that its approach makes much more realistic sense in handling the many complexities of ICT-based innovation. Accordingly, collaboration represents not just a moral argument (as it usually is); it shows that there are good reasons to assert a key principle of collaboration as the best rational approach in a reality of complex innovation social networks.

1 Participatory action research approaches e.g. Fals Borda & Rahman (1987) [96] express similar views.

12.4 FUTURE PERSPECTIVES

Collaboration can be made operational and hands-on for practitioners and students, as shown in the previous chapters. This is validated by users and underpinned with innovation and complexity theories. Despite the promising results and time plus effort it took to build this framework (almost 10 years), this is only a modest start. ICT4D as a process of innovation will require more field research. Since this book covers only the initial phases of the innovation process, research is needed to understand the mechanisms that lead to (or hamper) scaling-up and diffusion of technologies. More research is needed in the field of complexity and complex adaptive systems to better understand the nature of interactions between local agents, technologies and their physical and social environment (livelihoods). More field research, analysis and action are needed to understand the complex processes of sociotechnical innovation and its diffusion and preconditions for long-term sustainability of ICTs in low resource environments.

Concerning sustainability, more field research is needed on ICT4D business and value constellations to know how business innovation networks operate and evolve over time, in low resource, low tech environments. The e^3*value* model is a user-centered, networked approach, validated as a methodology that can be generalized for low resource context. Still, knowledge gaps may exist and contextual conditions have not yet been captured in current ontologies (see e.g. [278]).

When starting from the user needs, as shown in Figure 78, this raises new research questions, for example, concerning solutions for lack of (internet, electricity) infrastructure, for issues related to cultural aspects, such as modality and language, or to issues related to (local, distributed, networked, inexpensive, etc.) data services.

As the Internet will take a long time before it reaches poor remote regions[2], solutions are needed to extend the Web beyond the current Internet. Concerning technical infrastructures for internet-less regions, more research is needed into how to do decentralized service innovation, as infrastructure and affordability of ICT services may continue to be a large bottleneck in the diffusion of ICTs in remote, low resource environments. This will demand innovative solutions to "downscale" towards inexpensive, decentralized solutions and "small' data that fit low resource, low-tech environments [3], how to provide new ways of accessing and sharing knowledge such as radio and GSM phone etc. (see e.g. [26, 128, 313, 189]).

Concerning context-aware data services for local communities, further research is needed related to speech, e.g. resourcing of small local languages (see e.g. [166]) and

2 See e.g. open letter by Tim Berners-Lee 2018: https://webfoundation.org/2018/03/web-birthday-29/, (accessed 31-07-2019)

3 See e.g. research by Christophe Guéret, Victor de Boer, André Baart et al. 2018, https://w4ra.org/wp-content/uploads/2018/08/WEBIST_2018_6_CR.pdf, (accessed 31-07-2019), master thesis by Fahad Ali 2017, https://w4ra.org/wp-content/uploads/2017/12/machine-machine-communication-4.pdf, (accessed 31-07-2019)

voice technologies (see e.g. [315, 130]), integration of local and global data, how to organize and manage distributed local data, how to integrate different modalities of data (e.g. spoken data, icons, etc.), how to capture, process, link "small" local data [74, 75, 188], how to capture, represent, and link indigenous knowledge [187], how to tackle issues related to data security, data protection, intellectual property, how to harnass the potential of community-based open source software development and crowdsourcing and many other topics.

Furhermore, to scale up existing efforts and have more impact, an expanding, networked community of transdisciplinary ICT4D is needed, involving more researchers, more local users and more practitioners to further innovate, and generate new (open) knowledge in innovative ways.

12.5 THE 10TH PRINCIPLE FOR DIGITAL DEVELOPMENT: PUTTING THE LAST FIRST

As discussed in Chapter 1, in the past few years the international community of development donors and multilateral organizations, concerned with poor results of ICT4D practice, discussed and formulated nine Principles for Digital Development[4], the first principle reads: "Design with the User".

But who is this "User" ? Is the "User", for example, a doctor in a hospital in a developing country, a local representative of an international NGO, an educated urban person? Or is the "User" an illiterate farmer in a remote village in the Sahel? With other words: whom is ICT4D targeting? Those expected to be online in the next five years or does this also include the "last billion"[5], the most disadvantaged world citizens, grappling with lack of resources, environmental, political, economic hazards and vulnerable to the effects of climate change?

As pointed out in this book, it is possible to make ICTs serve the "last billion", even in the absence of literacy, purchasing power or infrastructure. But this requires inputs, time, (technical, social, organizational) skills, patience, perseverance, team spirit, commitment, and long lasting partnerships.

Whereas linear interventions have shown to be a recipe for failure and alternatives must be sought, we cannot claim that our proposed approach covers all the answers. Collaboration holds a promise – but no guarantee – of a just, democratic, inclusive process. But collaborative approaches can also be used for co-optation, for pursue of interests that may harm the users ([93]). Still, collaboration is to be preferred over interventionist approaches, based on positive, normative and phronetic grounds. Prudent judgement is required from the reflective practitioner who is confronted with conflicting, messy real world situations where aspects of poverty, livelihoods, interests and power may come into play.

4 https://digitalprinciples.org/, (accessed 31-07-2019)

5 According to Tim Berners-Lee the last billion will not be connected until 2042, https://webfoundation.org/2018/03/web-birthday-29/, (accessed 31-07-2019)

More efforts, research and practical action are needed to tackle the problems and needs of the least connected people. Therefore we propose, for ICT4D 3.0 a 10th Principle for Digital Development: "Putting the Last First" [52]. In this book we have proposed some ways how this additional Principle for Digital Development might be put into practice.

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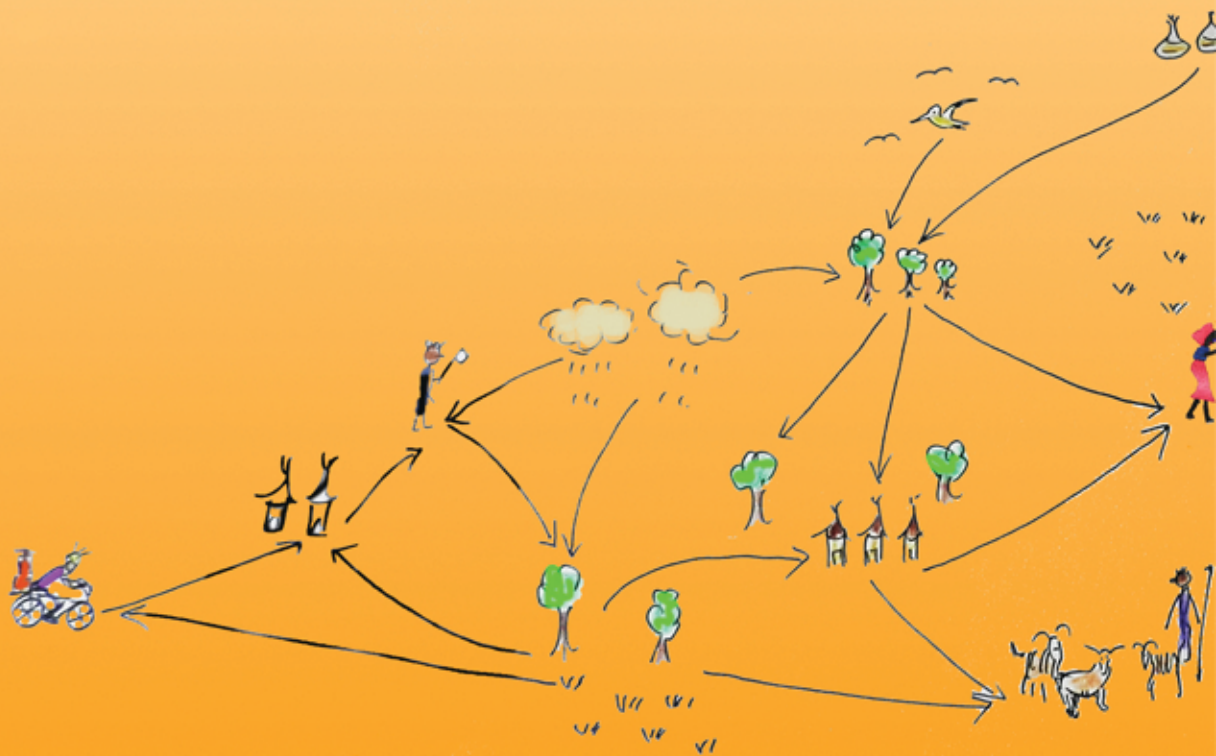
Be Collaborative is one of the key principles for digital development, formulated by influential multilateral development organizations, targeting people in poor and unconnected parts of the world. When reflecting on the meaning and purpose of this principle, the question comes up: how can one come to know what "the unconnected people" actually want, need or have interest in? This question is central for those who design and build information and communication technologies for development. The answer can only be obtained through dialogue and collaboration.

This book provides practical methods on how to develop information and communication technologies for people in low resource environments. The methods have been designed, developed and deployed in real world contexts and are illustrated with case studies from field research in rural areas of West Africa. This can be a source of information and inspiration for students and practitioners – experienced or new – in the field of ICT4D. It shows that socio-technical innovation is not a linear transfer of technologies, but a networked process, driven by local agency, diffusing and evolving in a complex world.



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