HEIDELBERG UNIVERSITY

MASTER THESIS

Community-based Mapping and Monitoring of Water Sources in Somaliland: An integrated approach combining Citizen Science and Forecast-based Financing

---

Author:
Bosse SOTTMANN

Supervisor:
apl. Prof. Dr. Sven LAUTENBACH

Examiner:
Prof. Dr. Alexander ZIPF

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science

in the

Institute of Geography
Faculty of Chemistry and Earth Sciences

April 16, 2023

Declaration of Authorship

I, Bosse SOTTMANN, declare that this thesis titled, "Community-based Mapping and Monitoring of Water Sources in Somaliland: An integrated approach combining Citizen Science and Forecast-based Financing" and the work presented in it are my own. I confirm that:

- This work was done wholly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date: 16.04.2023

Abstract

Community-based Mapping and Monitoring of Water Sources in Somaliland: An integrated approach combining Citizen Science and Forecast-based Financing

by Bosse SOTTMANN

Ensuring water security is considered as one of the major challenges of the twenty-first century. The trend of increasing demand and diminishing supplies is putting pressure on the availability of water worldwide. Particularly in the Horn of Africa, drought impacts determine the life of millions of people. Somaliland is in the midst of a years-long drought and water sources become more important than ever. Yet, information particularly about the most important water source type of berkads is incomplete and outdated.

Insufficient data availability can severely hamper disaster risk reduction measures, especially with regard to Forecast-based Financing (FbF), a proactive natural disaster response approach that has recently become increasingly widespread. Triggered by predicted disaster impacts, Anticipatory Actions (AAs) attempt to counteract impacts before the disaster occurs, rather than responding to post-disaster impacts. However, drought is a relatively novel application focus for this approach and is highly dependent on relevant information about local impacts.
One way to gather these information can be Citizen Science (CS), which has successfully been applied to provide data for acting on environmental issues primarily in North America and Europe. In addition, sub-categories of CS such as community-based monitoring, together with mobile crowdsensing, already form the conceptual backbone for the Somalia Red Crescent Society's health-related Community-based Surveillance project.
Building on the combination of these concepts, the aim of this study is to first develop a new and transferable approach for community-based participatory mapping and monitoring of water sources for water-scarce and resource-limited settings to facilitate relevant AAs in the context of FbF. This framework will subsequently be applied to create an implementation roadmap for the SRCS, ultimately aiming to improve water governance and information availability to address water scarcity in Somaliland.

The work is embedded in a primarily inductive design of an exploratory, iterative case study, and guided by a mixed-methods approach combining literature analysis and expert consultations. The results indicate that it is conceptually possible to integrate the concepts of FbF and CS for monitoring water sources in resource scarce settings to eventually trigger AAs within one framework. Moreover, in the case of Somaliland, it can also reasonably be assumed that the practical feasibility of this integrated framework is given. On this basis, future work will be able to integrate and assess local information in a pilot study, thereby overcoming the main limitations of this work due to resource, time and information constraints.

Acknowledgements

I would like to express my deep gratitude to Prof. Dr. Alexander ZIPF for providing me with the opportunity to write my thesis in the frame of the GIScience at the University Heidelberg.
To apl. Prof. Dr. Sven LAUTENBACH and *Dr. Michael Auer* for their time, continuous guidance and great humour during our numerous meetings.
To *Melanie Eckle-Elze* and the *HeiGIT Disaster Team* for their willingness to involve me in the project, practical help and encouraging support.

I would also like to express my gratitude to all interviewees for their valuable time and shared perspectives and experiences. Their contribution has been indispensable to the success of this study.

Special thanks to my *family*, *flatmates* and *friends* for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without you. Thank you.

Contents

List of Figures

List of Tables

List of Abbreviations

AA Anticipatory Action. 1, 2, 16, 17, 35, 37, 39, 55, 61–63, 65, 68, 69, 72, 81, 83–85, 87

BRCiS Building Resilient Communities in Somalia Consortium. 36, 37, 42, 47, 63, 74, 86

CBM Community-based monitoring. 2, 4, 19–25, 27, 29, 31, 63, 64, 72, 77

CBS Community-based Surveillance. 3, 4, 24–26, 36–38, 41, 42, 47, 61, 63, 64, 66, 71–73, 77–80, 82–84

CBWM Community-based Water Monitoring. 4, 24, 27, 29, 31, 38, 77, 79

CDRMC Somaliland Community Disaster Risk Management Committees. 36

CoCoRaHS Community Collaborative Rain, Hail and Snow Network. 23

CRTRMS Community Real-Time Risk Monitoring Systems. 37

CS Citizen Science. 2–4, 18–20, 25, 30, 38, 40, 43, 44, 46–48, 50, 55, 64, 74, 77–80, 83–88

DPIA Data Protection Impact Assessment. 25

DRM Disaster Risk Management. 35

DRR Disaster Risk Reduction. 3, 4

EA Early Action. 12, 13

EAP Early Action Protocol. 2, 4, 13–17, 35, 36, 40, 62, 67, 71, 81, 83, 84

FAO Food and Agriculture Organization of the United Nation. 8, 36, 41

FbA Forecast based Action. 14, 16

FbF Forecast based Financing. 1–4, 12–15, 38, 39, 42, 47, 51, 55, 61, 68, 77, 83, 86, 87

FEWSNET Famine Early Warning Systems Network. 36

FSNAU Food Security and Nutrition Analysis Unit. 36, 69

GRC German Red Cross. 1, 12, 36

GWP Global Water Partnership. 10

HeiGIT Heidelberg Institute for Geoinformation Technology. 1

IDMP Integrated Drought Management Programme. 10

IDP Internally Displayed Person. 62

IFRC International Federation of Red Cross and Red Crescent Societies. 2, 12, 14, 35–37, 47, 74, 79

IWMI International Water Management Institute. 11

IWRM Integrated Water Resource Management. 27, 29, 51, 54, 57, 70, 79, 81, 88

MCS Mobile Crowdsensing. 2, 4, 22–25, 29, 31, 38, 63, 64, 72, 77

MoAD Ministry of Agricultural Development. 68

MoH Ministry of Health. 63, 64, 72, 73, 86

MoWR Ministry of Water Resources. 63, 70, 72, 73, 86

NADFOR National Disaster Preparedness and Food Reserve Authority. 36, 42, 63, 86

NRC Norwegian Red Cross. 25, 36, 63, 64

OCHA United Nations Office for Coordination of Humanitarian Affairs. 36, 37, 63, 86

PRC Project-Requirements-Catalogue. 3, 40, 43, 47–49, 54, 74, 76–81, 84, 87

QA Quality Assurance. 45, 53, 55, 83

QC Quality Control. 45, 53, 55, 83

RCRC Red Cross Red Crescent. 2, 16, 64, 84

RCRCCC Red Cross Red Crescent Climate Centre. 2, 12

SLMC Seven-layer model of collaboration. 40, 43, 45, 47, 54, 74, 79, 84

SRCS Somalia Red Crescent Society. 1–3, 35–37, 41, 42, 61–66, 68, 69, 71–73, 78, 81, 83, 87

SSDR Six-Stage-Design-Roadmap. 3, 40, 47, 48, 54, 55, 74, 76–80, 87

SSF Six-Stage-Framework. 40, 43–48, 74, 77–79, 84

SWALIM Somali Water and Land Information Management. 36, 41, 62

UNDRR United Nations Office for Disaster Risk Reduction. 36

WFP United Nations World Food Programme. 36

WHO World Health Organization. 36, 64

WMO World Meteorological Organization. 1, 10, 36

WPI Water Poverty Index. 11

Chapter 1

Introduction

Water is a crucial element for sustaining life, and access to it is a fundamental necessity for every society and human being. Nonetheless, water security is increasingly becoming a pressing issue affecting the lives of billions of people across the world (Caretta et al., 2022). In order to meet this challenge, the United Nations have already recognized the importance of water security in 2015 and have made clean water and sanitation the sixth Sustainable Development Goal (UN, 2016). Yet, in many regions water scarcity as a long-term water supply and demand imbalance is expected to further deteriorate leading to the recent announcement of the World Meteorological Organization that *"water scarcity [...] is one of the greatest challenges of the twenty-first century"* (IDMP, 2022, p. 7).
Droughts, known for their widespread and potentially extreme impacts, can further exacerbate a strained water scarcity situation (IDMP, 2022). With the projection of rising frequency and intensity of droughts throughout vast parts of the African continent, measures for prediction, monitoring and evidence based Anticipatory Actions (AAs) and management become ever more important (Abdulkadir, 2017; Trisos et al., 2022; UNDRR, 2021).
As Somaliland is characterised by a semi-arid four-season climate with two extended dry seasons and an economic backbone of pastoralism and rain-fed agriculture, access to water is crucial (Abdulkadir, 2017; Petrucci, 2022; Republic of Somalia, 2021). Furthermore, Somaliland is no exception to the above mentioned climatic trend and with more than 17 major droughts in the last 60 years, a recent famine in 2010-2012, and an increasingly devastating situation again since 2018, Somalia is severely affected by droughts (Abdulkadir, 2017; CRED, 2023). The final report of the Forecast based Financing (FbF) feasibility study identified five other hazards besides drought, namely floods, cyclones, diseases, locusts and conflict. But of all these hazards, drought was ranked as the greatest threat due to its increasing frequency, severity and far-reaching consequences (SCRS, 2022).

The presently but also generally very challenging water resource situation in Somaliland requires comprehensive, effective and efficient solutions. The Somalia Red Crescent Society (SRCS), German Red Cross (GRC) and Heidelberg Institute for Geoinformation Technology (HeiGIT) are currently working together to develop strategies to prepare for these disasters. However, it has become apparent that many drinking water related activities are severely limited in their feasibility as information on most water sources is either incomplete, outdated or non-existent. Therefore, the SRCS calls for new and innovative approaches to close this information and management gap.

The FbF programme was generally started in 2007 by the Red Cross Red Crescent Movement together with the Red Cross Red Crescent Climate Centre to facilitate AAs instead of post-disaster reactions (IFRC & GRC, 2019). Together with their local partners, the International Federation of Red Cross and Red Crescent Societies (IFRC) is working on establishing so called Early Action Protocols (EAPs) to ensure better organization and coordination of AAs in the face of an incoming disaster. These AAs are based on a predefined interplay of evidence based forecasts, triggers, actions and financing mechanisms to ensure rapid reactions.
Triggering AAs is generally linked to certain forecast thresholds. Once these thresholds are reached, the AAs are carried out. The forecasts are generally based on drought indicators and indices, which mostly include only physical indicators and are primarily macro and international in scope (Svoboda et al., 2016). Fine grained up-to-date forecasts which also include social realities and knowledge on local levels are rare or even non-existent (Enenkel et al., 2020; Masinde & Bagula, 2010). "However, assessments focused only on physical variables and processes fail to capture why drought matters [...]."(Lackstrom et al., 2022, p. 3) and how it directly impacts communities (Boult et al., 2022; Enenkel et al., 2020).
One way for more on site information is the involvement of local citizens. Engaging local citizens and communities into monitoring activities and decision-making can be of multiple benefit to a wide variety of aspects (Njambi-Szlapka & Jones, n.d.; SCRS, 2022). Scientific processes of e.g. linking climate variability to local water security can be informed, the public's education and awareness about specific topics can be raised, and decision-making and overall management can be enhanced (Huang et al., 2020; Kirschke et al., 2022; Minkman, 2015). The IFRC states, that the "community engagement and accountability (CEA) is essential [...] to build acceptance and trust" for effective and sustainable outcomes" (IFRC, n.d.).

In the last two decades, Citizen Science (CS) has become a vibrant area of scientific interest covering various aspects in many different contexts (Kirschke et al., 2022; Kullenberg & Kasperowski, 2016). Relatively recent developments in Community-based monitoring and Mobile Crowdsensing now make it possible for a large number of citizens to contribute to scientific, social and environmental endeavours with just a simple phone (Butte et al., 2022). By applying these approaches, CS projects have demonstrated their ability to gather and fill data gaps particularly in formerly data sparse regions in an effective and cost-efficient manner (Butte et al., 2022; Lackstrom et al., 2022; Weeser et al., 2018). However, environmentally and ecologically oriented projects and studies are currently unevenly distributed around the world, with a focus on North America, Europe and Australia, which considerably limits the amount of guidance available for other contexts (Canada et al., 2018; Kirschke et al., 2022; Koehler & Koontz, 2008). Furthermore, most of these projects require internet access and dedicated technical equipment, which makes their methods unsuitable for low-income contexts (Fienen & Lowry, 2012; Lackstrom et al., 2022; Lowry et al., 2019).
Most developed frameworks and guidelines therefore primarily represent experiences and applications from potentially very different contexts and only roughly comparable thematic foci.

However, broadly comparable projects show the general applicability of participatory monitoring approaches also in the Global South (Gualazzini, 2021; IFRC, 2017; OCHA, 2020; Weeser et al., 2018). In particular, the Community-based Surveillance project established by the SRCS and others to facilitate preventive health related activities in Somaliland indicates the local implementability (IFRC, 2017; SCRS, 2022).

Building on the concepts of FbF and CS, developed methods, and experiences gained from thematically comparable projects and from local implementations, this work attempts to *first develop a new and transferable framework for community-based participatory mapping and monitoring of water sources for water-scarce and resource-limited settings to facilitate relevant AAs in the context of FbF, and then apply this framework to create an implementation roadmap for the SRCS, ultimately aiming to improve water management and information availability to better address water shortages in Somaliland proactively*.
This study follows a primarily inductive research design of an exploratory, iterative case study, adopts a mixed-method approach with data and document analysis, as well as expert interviews and is oriented around two research questions:

RQ1. How can a replicable and transferable framework for community-based participatory mapping and monitoring of water sources be developed with regard to the research aim in overall contexts such as those in Somaliland?

RQ2. In the specific context of Somaliland, how can the developed framework be applied to create a tailored roadmap for the implementation of a community-based participatory water source mapping and monitoring project for triggering Anticipatory Actions to address water shortages?

For the purpose of answering these research questions, this thesis is structured as follows: Chapter 2 introduces fundamental concepts such as Water Security, Drought, and Water Scarcity and provides an overview of the concepts and sub-concepts of FbF and CS. Furthermore, the case study area of Somaliland is presented in this chapter, covering its climate, geography, socio-economic situation and current Disaster Risk Reduction developments. Chapter 3 provides an overview of the methods used in this thesis and briefly introduces the two main underlying frameworks and other related guidelines that inform the new design. The following Chapter 4, presents the newly developed community-based water source monitoring Six-Stage-Design-Roadmap (SSDR) and Project-Requirements-Catalogue (PRC) framework and subsequently outlines the resulted implementation roadmap of applying this framework in the context of Somaliland. The following discussion of the developed design framework, the findings of the application, as well as the elaboration on the general limitations of this work are dealt with in Chapter 5. The conclusion in Chapter 6 summarises the main findings, reflects on their contribution to science and practice and provides an outlook for further work.

Chapter 2

Theoretical Background

2.1 Introduction

This chapter provides an overview of the theoretical background of this thesis, including key concepts, theories and literature in which this thesis is embedded. The chapter starts with a discussion of broad concepts such as *water security*, *water scarcity*, and *drought*, along with their characteristics and differences in section 2.2. Building on this foundation, the section 2.2.4 introduces the approach to measure and monitor these wide concepts through indicators and indices together with the ideas of risk, vulnerability, and impact. Extending the prevailing idea of the Disaster Risk Reduction (DRR) cycle of mitigation, preparation, response and recovery, the rather recently emerged concept and operationalisation of *Forecast based Financing (FbF)* is described in detail. The details cover aspects of the Early Action Protocol structure, forecast based decision-making, setting strict thresholds for when to act, and finally what to do when thresholds are exceeded.
Drawing on the realisation that the current data basis for predictions is too coarse for precise measures, another broad field *Citizen Science (CS)* is introduced in section 2.4. Following this, sub-concepts of Community-based monitoring (CBM) and Mobile Crowdsensing (MCS) are further introduced and with Community-based Surveillance (CBS) and Community-based Water Monitoring (CBWM) concise examples for successful implementation in local context and thematic transferability of the approach are given, respectively.
Section 2.5 anchors the concepts mentioned so far in the local context and addresses local specifics. The geographical and climatic conditions, the historical and current political and socio-economic context, and ongoing implementation efforts for anticipatory measures further describe the case study area of Somaliland. The chapter concludes with a summary of the key take aways and establishes a link between the findings and the further thesis.

2.2 Fundamental Concepts

Water security is a theoretical construct that has emerged in the 21st century to frame the overall water objectives and goals to guide local to global water management and policy development (Sadoff et al., 2020). It "links together the web of food, energy, climate, economic growth, and human security challenges that the world economy faces over the next two decades" (WEF,

2009, p. 5). In more detail, it is about "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies" (Grey & Sadoff, 2007, p. 1).
Water security integrates therefore economic, social and environmental dimensions into an interconnected and complex network of human and natural relations by addressing risks of too much, too little or poor quality water (Mishra et al., 2021; Van Beek & Arriens, 2014). Due to the focus of this work, emphasis is placed on factors that decrease water security due to too little water availability. Besides other factors, natural disasters such as droughts, and water scarcity are the main drivers for insufficient quantities of water (Caretta et al., 2022). Water quality and access are briefly addressed in addition to provide a more comprehensive understanding of water security for the following chapters.

2.2.1 About Drought

Drought as highly complex and severe climate-related multi-hazard has far reaching, cascading and interconnected consequences affecting natural ecosystems, societies and economies, see figure 2.1 (UNDRR, 2021). Historically, droughts are a recurring feature that can occur in all climates. They can geographically extend over small areas to entire sub-continents and are slow onset events that can persist for a few weeks to several years. These high spatial and temporal variabilities make drought not only challenging to define but due to its slow onset, droughts are often only recognized when they are well advanced (IDMP, 2022; UNDRR, 2021).

While some drought conditions over large areas can be associated to some low-frequency changes in atmospheric conditions such as the El Niño, accurate cause identification can be rather challenging on smaller scales and requires many different parameters (Botai et al., 2019; UNDRR, 2021). This complex conglomeration of interrelated causes and effects of multiple temporal, spatial and thematic dimensions makes the definition of *drought* a fairly multi-layered undertaking (Balint et al., 2013). Several well-known definitions are, for example, the dictionary of the English language (2022) defines drought as "a long period of abnormally low rainfall, especially one that adversely affects growing or living conditions". Palmer (1965) defines drought as "a prolonged and abnormal moisture deficiency" (p.2) and Van Loon et al. (2016) defines droughts simply as "temporary lack of water compared to normal conditions" (p.3637). Other drought definitions emphasize its natural and human origin, its special characteristics, impact and temporal duration or even understand "drought as a system of causality where the link between causes and effects is random in nature" (Balint et al., 2013, p. 3). Already in the 1980s, Wilhite and Glantz, 1985 found more than 150 published definitions of drought. Besides the categorization into a conceptual or operational category, Wilhite and Glantz (1985) proposed a clustering of these definitions into four types, namely meteorological drought, agricultural drought, hydrological drought and socio-economic drought. This classification is still widespread today (Balint et al., 2013; Balti et al., 2020; IDMP, 2022; UNDRR, 2021).
The conceptual category refers to a general formulation of an idea of drought to understand its concept and identify its boundaries and is often formulated in relative terms (Wilhite & Glantz,

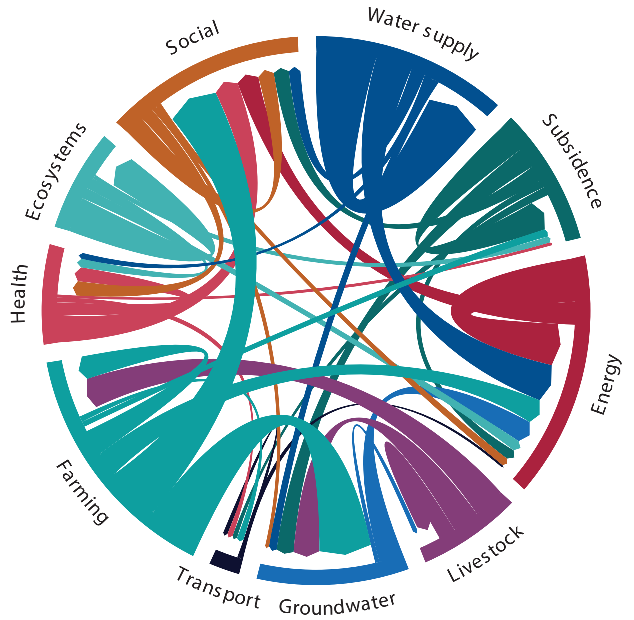

FIGURE 2.1: Schematic representation of potential interconnections among different sectors affected by droughts. Note: Each sector is represented by a fragment on the outer part of the circular layout. Arcs are drawn between each sector with the size of the arc being proportional to the importance of the trade-off. Source: UNDRR (2021, p. 47)

1985). Definitions in the operational category try to define how drought functions in terms of its onset, duration, severity and spatial coverage also covering how this can be measured via indices (Balint et al., 2013; NDMC, 2023b; Wilhite & Glantz, 1985). With these definitions, the current situation is usually compared to a historical average, which is usually based on a 30-year period, presupposing the development and continuous measurement of indicators and indices that can be used (UNDRR, 2021; Wilhite & Glantz, 1985). The four types of drought are commonly conceptually defined and brought into practice by operational specifications. They can be understood as different, but complementary stages of the same process and are generally cascading in reason and time but can overlap and are difficult to completely unravel.

The *meteorological drought* is usually characterized by the duration and the degree of dryness in comparison to the normal average and tries to conceptually understand how weather patterns can impact water availability. Definitions in this category are specific for a region's atmospheric conditions. That is to say that regions with a year-round precipitation regime such as the tropical rainforest need different definitions and thresholds than e.g. climates characterized by seasonal rainfall patterns (NDMC, 2023a). Operational classification mostly uses rainfall, moisture, temperature and wind indicators to determine the onset, severity and duration of drought.

Agricultural drought definitions establish a connection between different features of meteorological drought with their impacts on agriculture. Soil-moisture, differences between actual and potential evapotranspiration and soil water deficits are some of the operationalized indicators for monitoring this type of drought (Balti et al., 2020; NDMC, 2023a).

The type of *hydrological drought* is associated with the impact of meteorological drought on surface or subsurface water resources such as rivers, lakes, and groundwater. Hydrological drought occurs when these indicators drop below normal levels (Palmer, 1965). The fastest responding indicator of this type of drought is most often the variability of streamflow. The water levels of lakes and groundwater usually lag behind the occurrence of the meteorological or agricultural drought which is why the hydrological drought is often out of phase with the previously mentioned types. The hydrological drought is commonly defined on the basis of watershed or river basin scale (Balti et al., 2020; NDMC, 2023a; Wilhite & Glantz, 1985).

The *socio-economic drought* differs from the aforementioned types as it can also incorporate features of these types of drought to associate them with the demand and supply of some social or economic good. It therefore relates the impact of all other types of droughts on human population and its various sectors of society such as food security, health, and economy. It is therefore sometimes also interchangeably used with drought impact. Operational categorization involves using socio-economic indicators such as unemployment rates and food prices to assess the severity and duration of the drought (NDMC, 2023a; Wilhite & Glantz, 1985).

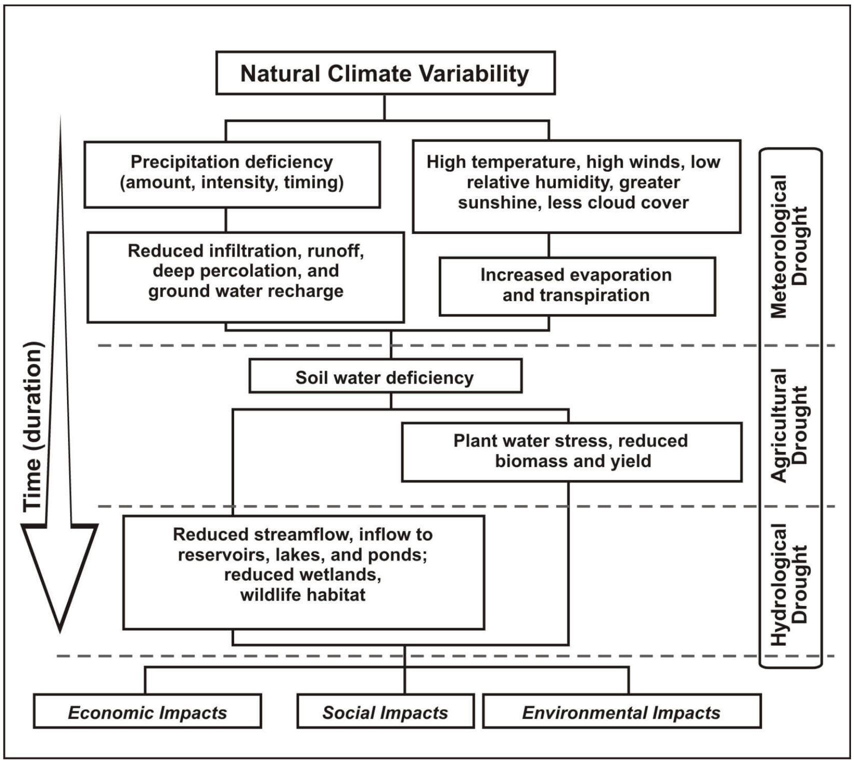

FIGURE 2.2: Sequence of drought occurrence and impacts for commonly accepted drought types. Source: NDMC (2023a)

The shown economic, social and environmental impacts of drought in figure 2.2 depend on the severity of, and the risk to drought. These three concepts of impact, severity and risk are interrelated concepts used to assess and understand the effects of drought on various sectors.

Thereby, in alignment with the definition of Van Loon et al. (2016) it is the exceptional severity of the water shortage that distinguishes drought from aridity, an ordinarily recurrent or fully dry climate, and from water scarcity as a long-term "supply/demand and natural and/or human-made phenomenon" (IDMP, 2022, p. 7). Water scarcity is described in more detail in the following chapter.

2.2.2 Water Scarcity

Water scarcity, as for water security or drought, is defined in many different ways. The sixth IPCC Assessment Report defines water scarcity broadly as "a mismatch between the demand for fresh water and its availability, quantified in physical terms" (Caretta et al., 2022, p. 560). The focus here is primarily on physical water scarcity, with the social and economic components being outsourced to the broader concept of water security and insecurity (Caretta et al., 2022). In contrast, the Food and Agriculture Organization of the United Nation (FAO) defines water scarcity as "a gap between available supply and expressed demand of freshwater in a specified domain, under prevailing institutional arrangements (including both resource 'pricing' and retail charging arrangements) and infrastructural conditions" (p.5) further summarizing that water scarcity is "an excess of water demand over available supply" (FAO, 2012, p. 6). Thus, highlighting the human dimension of this interactive and relative concept of physical and economic water scarcity. Hereby, physical water scarcity refers to a situation in which there is not enough water available in quantitative terms to meet demand. Economic water scarcity on the other hand occurs when inadequate infrastructure, institutional or financial capital impede access to water resources "even though water in nature is available to meet human demands" (Molden et al., 2007, p. 11).

Water scarcity and drought can be linked in complex ways. Potential mutual reinforcements, climate change, increased water use and poor water management can further make it difficult to clearly separate these concepts (IDMP, 2022; Leal Filho, Totin, et al., 2022; Liu et al., 2017; RCRC, 2020). Nonetheless, following the definition of FAO (2012) the concept of water scarcity always gives water shortage, understood as absolute lack of water in the current situation, a human dimension in particular on the demand side. Here, the quality of policies, planning and management is considered as critical to the overall severity of the impact of water scarcity (FAO, 2012; IDMP, 2022; UNDRR, 2021). The supply side can be influenced by human activities, but it is not a mandatory prerequisite (IDMP, 2022).

Besides the already mentioned water scarcity on the basis of physical quantity and economical factors, water scarcity can also be caused by water of unacceptable quality and lack of access to water services (FAO, 2012). The recognition that insufficient water quality is an additional contributing factor to water scarcity is a relatively recent development in the literature but together with inadequate access highlights further challenges in ensuring water security (Caretta et al., 2022; Liu & Zhao, 2020; Mishra et al., 2021).

2.2.3 Water Quality & Access

As could be seen in the previous section, besides the quantitative availability of water, its accessibility and quality are crucial. Inadequate water quality can be related to numerous health and environmental issues and can further limit the availability of water for given uses (FAO, 2012; RCRC, 2020). Unlike the previous concepts, water quality has mostly fixed indicators by which the condition can be determined. Historically, and still today, water quality assessment is primarily carried out in laboratories with preceding water sampling activities. This procedure not only makes the determination of water quality a laborious and costly process, but also places high demands on equipment and personnel, so that it is not yet viable for large-scale rural assessments in low-income areas (Tariq et al., 2021; WMO, 2013). While simpler methods for in situ water quality monitoring exist, they are either insufficient or often still need too much investment and knowledge to conduct for widespread and frequent monitoring (WMO, 2013). Nonetheless, new solutions are being developed to simplify and scale affordable water quality assessments to rural areas (Ighalo & Adeniyi, 2020; Tariq et al., 2021). While the direct assessment of water quality might be challenging, poor water quality can be linked to other factors. Environmental awareness, poor sanitation and hygiene conditions of people in rural areas, for example, were considered as major causes for contamination of water at source (Zamxaka et al., 2004).

The definition of water access is again a rather challenging undertaking. The World Bank (1997) defined water access in rural areas by "access implies members of the household do not have to spend a disproportionate part of the day fetching water" (p. 254). While both time and distance still play a crucial role in literature when investigating water access (Cassivi et al., 2019, 2021; Emenike et al., 2017), the term also gained a social component (Emenike et al., 2017; Mitlin et al., n.d.). Obeng-Odoom (2012) adds three additional factors namely, affordability, quality, and equitable distribution to the definition of water access to fully understand if users have access to water in daily live. United Nations (2002) links these parameters to the access of an improved water source which should provide safe drinking water. The access to improved water sources is therefore generally considered as crucial in the reaching of water security (CDC, 2022a).
Proactive measures to drought and water scarcity can not only potentially minimize or even neutralize impacts and are considerably more cost-efficient, early warning and anticipatory actions for drought and water scarcity impacts become ever more important (FAO & UN-Water, 2021; IDMP, 2022; World Bank, 2016).

2.2.4 Indicators & Indices

Indicators and indices are often used to translate complex matters into easier to explain numbers and scales that can be measured, tracked and reasonably compared (Blauvelt, 2014; Williams & Eggleston, 2017). This can range from capturing simple measurements to complex and detailed issues that can not only depict ecological conditions but its interactions with societies (Blauvelt, 2014; Mishra et al., 2021). Indicators and indices can thus establish a clear and common understanding of a concept or parts of it in a quantifiable and more objective way.

Here, an *indicator* is understood as a measurable parameter that provides information on the state or trend of an issue or problem. It can be a physical, chemical, biological, or socio-economic variable, such as temperature, soil moisture or streamflow and can be measured locally or remotely. An *index* is a composite measure that aggregates multiple indicators into a single value or score (Svoboda et al., 2016; United Nations University, 2017; Williams & Eggleston, 2017). Indices are developed at regional or national level to take account of specific circumstances, or at international level to understand large-scale phenomena (United Nations University, 2017). This case specification, together with different measurement and aggregation methods, partial inconsistency of definitions and differently focussed objectives on qualitative, quantitative, risk or impact scenarios can constrain their practical application and intercomparability (Svoboda et al., 2016; United Nations University, 2017). Since there is no one definition of drought, water scarcity or security, there is no one best solution to the choice between the many indicators and indices for either of those. However, the indicator or indices should be aligned with the specific definition when put into practice.

Precipitation, evapotranspiration, soil moisture, lake and groundwater levels, streamflow and vegetation water stress are among the most prominent drought indicators (Observatory, 2017). These and other indicators will be aggregated into various drought indices to adequately describe the different drought stages. Among the most prominent meteorological drought indices are the Standardized Precipitation Index *SPI* together with its extension the Standardized Precipitation-Evapotranspiration Index *SPEI* (NCAR, n.d.-a, n.d.-b; Observatory, 2017). These indices compare the standardized departure of observed accumulated precipitation (and evaporation in the case of SPEI) from reference data for a given time period (NCAR, n.d.-a, n.d.-b). Agricultural drought indices like the Soil Moisture Anomaly *SMA* or the Anomaly of Vegetation Condition *FAPAR Anomaly* are based on soil moisture indicators and absorbed radiation fractions, respectively. By quantifying water flow volumina, the Low Flow Index *LFI* belongs to the hydrological drought indices (Observatory, 2017; Svoboda et al., 2016). In addition to these and other types of indices, such as Combined Drought Indices, the *Handbook for Drought Indicators and Indices* lists over 50 drought indicators and indices. For further and more in-depth information, please refer to the interactive website of the Integrated Drought Management Programme (IDMP) launched by the World Meteorological Organization (WMO) and Global Water Partnership (GWP) (IDMP, 2021).

All of these drought indices give a good impression about the physical side of climate anomalies, but none of the above mentioned indices link those climate anomalies to socio-economic vulnerabilities (Enenkel et al., 2020). Mishra et al. (2021) argue, that the framing of water security challenges extends beyond singular indicators. Lackstrom et al. (2022) take this argument further, in saying that assessments that only consider physical factors overlook the broader impact of drought on social, economic, and ecological systems.
The simple but widely used Falkenmark Indicator incorporates human factors by calculating a ratio between the given amount of water and the number of people living within that domain (Falkenmark et al., 1989). By further categorizing this ratio to a level of water scarcity, the Falkenmark Indicator describes the supply side effects of water scarcity. However, variabilities,

demand and socio-economic factors are not represented.
More dedicated indices like the International Water Management Institute (IWMI) Indicator and the Water Poverty Index (WPI) as well as other indices measuring water security give a more extensive representation of the overall situation (Arreguin-Cortes et al., 2019; Liu et al., 2017). The WPI for example represents the weighted average of five pre-standardized components namely, water availability, access, capacity, use and environment (Sullivan et al., 2003). However, the information on all these indicators is not always available and they often remain quite coarse spatially, making them mostly unsuitable for operational measures.

Determining the right set of indicators and indices for a given region to e.g. assess hazard severity depends on the objective and available data and is often a balancing act between many factors and circumstances (Svoboda et al., 2016). Besides the pure description of what certain natural or social circumstances **are**, there is a growing interest to understand what these conditions will **do** (Boult et al., 2022; Lackstrom et al., 2022).
The effects of these conditions on the ground are most often called the *impact* of a certain weather phenomenon or climate development such as a drought hazard. Impacts can be direct or indirect and are generally difficult to quantify economically (UNDRR, 2021). The level of impact is commonly determined based on the severity of the hazard, the exposure of the investigated elements and their respective vulnerabilities (Harrowsmith et al., 2020; Svoboda et al., 2016; UNDRR, 2021). This concept is generally expressed by the risk equation

$$Risk = f(Hazard, Exposure, Vulnerability)$$

where

$$Vulnerability = f(Level\,of\,Coping\,Capacity, Level\,of\,Adaptive\,Capacity)$$

(Boult et al., 2022; Harrowsmith et al., 2020; UNDRR, 2021)

The *hazard* can be evaluated and described by the above mentioned indicators and indices with difficulties lying in the contextualization and setting of the threshold levels to separate between fluctuations within the normal range and extreme events. *Exposure* is commonly defined as social, economic, cultural or natural assets, services or resources in places that could be adversely affected by a hazard (IPCC, 2014). Exposed elements can be more ore less vulnerable to the hazard. *Vulnerability* conditions are determined by the sensitivity or susceptibility of a system, community or individual to physical, social, economic or environmental factors or processes (IPCC, 2014). These conditions are often further described as the level of coping and adaptive capacities. *Coping capacities* refer to available skills and resources of systems, organizations or individuals to address, manage and overcome unfavourable circumstances (IPCC, 2012). In the same manner, *adaptive capacities* relate to preparation, reduction and moderation of those impacts.
The establishment of a functional relationship between the hazard, exposure and vulnerability to assess its impact can be rather difficult for numerous reasons and is further discussed

by Boult et al. (2022) for interested readers. Moreover, all these factors change over time, so that the quality of the calculations depends strongly on the up-to-dateness of the data basis (Harrowsmith et al., 2020).

An understanding of the severity of droughts and their current local impacts enables targeted responses as well as to allow for the development of future predictions based on current conditions. However, most of the current drought or water scarcity indicators do not capture the required level of detail and impact that is required to operationally act upon (Bartram et al., 2014; Mishra et al., 2021). Also, while the complexity of these concepts is due to the level of complexity of the surveyed phenomenon, its application and comparison is hindered. Thus a method to assess local impact, that builds and incorporates these concepts in a practically applicable manner is needed to better facilitate recent efforts that increasingly emphasize proactive and forward-looking measures in disaster relief initiatives. The forthcoming section will explore this relatively recent shift towards proactivity and its implications for improving drought and water management strategies.

2.3 Forecast based Financing

Traditionally, disaster management efforts have primarily focused on long-term preparedness or post-disaster response, thus only providing direct assistance and relief to affected communities after a disaster has occurred (Coughlan de Perez et al., 2015; UNISDR, 2005). The lack of standardized procedures for forecast-based actions led to disaster warnings often going unheard (Kolen et al., 2013). In the context of increasing frequency and severity of natural disasters, coupled with the influences of climate change, the need for a more proactive approach that can reduce the impact of disasters on vulnerable communities became apparent (Coughlan de Perez et al., 2015; Trisos et al., 2022).
Nonetheless, for the time being, funding was strongly focused on the post-disaster response and incentives to invest in new and complex scientific developments including relatively high uncertainties were limited (Coughlan de Perez et al., 2016). This changed with the development and successful integration of several new forecast-based financing systems that utilized the opportunity gap between a forecast and the disaster to successfully reduce corresponding impact. Based on this, to "substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030" (p.12) became one of seven global targets of the Sendai for Disaster Risk Reduction 2015-2030 framework (UNDRR, 2015). Today, large institutions have now specialized sections for the financing of Early Actions such as the Climate Risk and Early Warning Systems Initiative (CREWS) and the Global Risk Financing Facility (GRiF) to support and backup Early Actions (CREWS, n.d.; World Bank, n.d.). Forecast based Financing has thus emerged as a promising approach to disaster management that enables proactive, timely, and cost-effective responses to disasters (Coughlan de Perez et al., 2015; GRC, 2017). The International Federation of Red Cross and Red Crescent Societies (IFRC) together with the Red Cross Red Crescent Climate Centre (RCR-CCC) and German Red Cross (GRC) have developed and improved the FbF programme to

fund EAs since 2007 (IFRC & GRC, 2019).

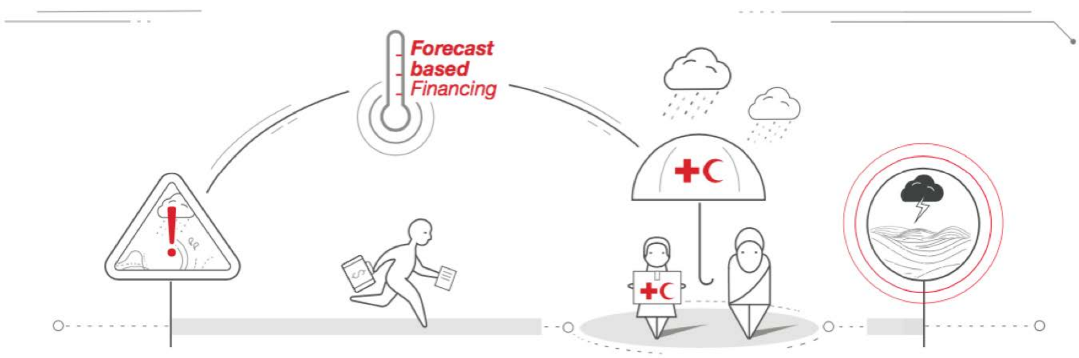

FIGURE 2.3: FbF Diagram. Source: RCRC (2020)

Following (Coughlan de Perez et al., 2015; Coughlan de Perez et al., 2016) the structure of FbF can be distilled down to:

> "When forecast states that an agreed-upon probability threshold is exceeded for a hazard of a designated magnitude, then an action with an associated cost must be taken that has a desired effect and is carried out by a designated organisation." (Coughlan de Perez et al., 2016, p. 2)

Thus, the FbF approach involves three key components (1) triggering (2) pre-defined EAs and securing a (3) financing mechanism in advance, see figure 2.4 and IFRC and GRC (2019). Early Action Protocols provide a summary of the three components (Rüth et al., 2017).

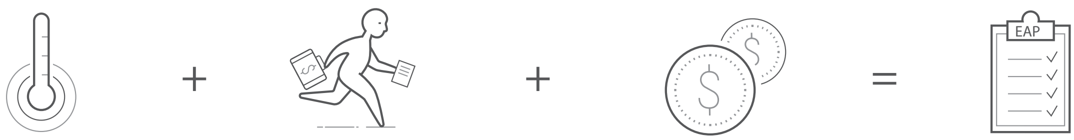

FIGURE 2.4: Early Action Protocol. Source: IFRC and GRC (2019)

2.3.1 Early Action Protocol

In the Early Action Protocol (EAP) triggers, actions to be taken and financing mechanisms are clearly outlined. In addition, responsibilities are summarised and explicitly assigned to involved actors to ensure that everyone knows and understands their role and task in case of activation (Rüth et al., 2017). This leads to clear accountability and full commitment from all stakeholders, facilitating the timely and efficient implementation of the predetermined actions (Rüth et al., 2017).
Two types of analyses, namely the identification of forecasts and the risk assessment, form the basis for specifying the trigger, affected regions, and selected actions in the EAP, see figure 2.5.

Both, forecasts and risk assessments are primarily based on historic data and experiences. To identify suitable forecasts, different forecasts are compared and examined for their ability and

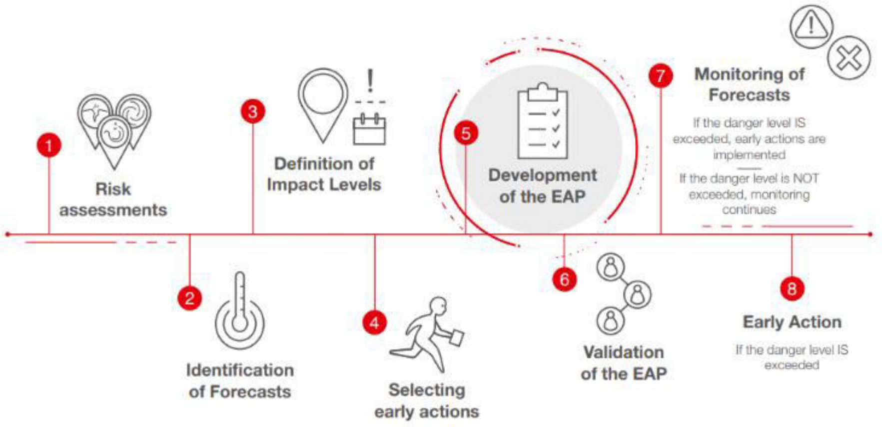

FIGURE 2.5: Overview of EAP Development Stages. Source: GRC et al. (2019)

performance in predicting past hazards. Ultimately, a specific impact threshold based on one or a combination of several impact-based forecasts becomes the basis for triggering actions. This trigger also depends on the outcome of the risk assessment, as the impact of the hazard is highly influenced by the risk on site, see section 2.2.4 (IFRC & GRC, 2019; IFRC et al., 2023b).

The risk assessment is a complex analysis that takes into account numerous factors on the scale of the hazard and its sub-hazards, exposure, and vulnerability with its coping and adaptive capacities (IFRC et al., 2023b). Possible bases for analysis strongly depend on the respective hazard and can range from records of historical events, housing location and building structures in the case of hurricanes and floods to social factors like income, demographics and school attendance. The objective is to identify the relevant impacts and their magnitude in order to determine the most effective measures and allocate resources as objectively as possible. However, most of these parameters are proxies, as direct information on local impacts is rare, outdated, of low accuracy or quality (IFRC et al., 2023b).

Due to the majority of the implemented EAPs concentrating on fast onset disasters such as floods, hurricanes or strong rains, the Forecast based Financing concept was primarily focussed and developed in this regard. In this context, a solitary trigger and its corresponding actions are typically established, with a strong emphasis on rapid response given the narrow window of less than 48 hours between activation and the potential onset of disaster (RCRC, 2020). Drought as a usually slow-onset hazard, on the other hand, pose unique structural challenges to the process of determining thresholds to trigger actions as impact builds up over time and is highly dependent on the context (Boult et al., 2022). These challenges of identifying a forecast, determining a trigger and selecting actions are further outlined in the coming chapters.

The specification of the financing mechanism as one of the three key components that will not be covered in any further detail in this work, as this is covered and decided by the overlying EAP development. Generally, the IFRC has extended their Disaster Relief Emergency Fund (DREF) with Forecast based Action (FbA) as dedicated mechanism to adequately support their increased numbers of FbF projects. Once the forecast-based trigger is met and the EAP is activated, the financing mechanism automatically assigns resources. This solves the issue of financing to a large extent and is therefore no longer a major restriction for FbF projects.

2.3.2 Forecast Selection

Indicators and indices as discussed in chapter 2.2.4 measure the severity, duration and spatial coverage of hazard conditions based on historical and current data. They provide a snapshot of past and present conditions and serve as an indicator of the overall situation. Forecasts, on the other hand, use these indices together with climate models and data to predict future conditions and provide early warning of potential hazard events. Thus, forecasts extend the retrospective and current measures of indices to future prediction.
Similar to the indices, a single forecast usually only covers certain facets of a hazard. In the case of droughts, the thematic orientation commonly follows its definition classification into meteorological, hydrological and agricultural subdivisions. Furthermore, forecasts can additionally be categorized into global, continental or regional spatial scales with coarser scaling predictions mostly correlating with longer time spans and vice versa (Balti et al., 2020). Global to continental meteorological drought forecasts with the focus on seasonal or inter-seasonal predictions are often based on same scale phenomenons such the Julian-Madden Oscillation, the ENSO cycles or the Indian Ocean Dipole (Anderson et al., 2022; Gore et al., 2020; Yuan et al., 2008). These conditions are mostly collected through satellite and global weather monitoring networks often utilizing drought indices such as the SPI, SPEI and EDDI indices (J.-S. Kim et al., 2021). Further drought prediction services such as the National Integrated Drought Information System of the US government, the European Drought Observatory (EDO) or its adaptation, the East African Drought Watch, utilize a wide range of different indices to predict hazard developments and their impacts (ICPAC, 2023; NIDIS, 2023; Observatory, 2017). These institutions also produce timely forecasts, but their data sources are usually based on the same remote evaluations mostly predicting what the weather and climate will be, and not what its implications on the ground will look like (Enenkel et al., 2020).

The transition to impact-based forecasts represents a radical shift in the way these forecasts are produced and operationalized (IFRC et al., 2023b). Practically, this changes the information that a forecast provides from predicting e.g. precipitation patterns to forecasting the magnitude and spatial coverage of crop failure, for example (Harrowsmith et al., 2020). The challenges of functional relationships, complex interconnected cause and effect networks and data availability mentioned in section 2.2.4 are also applicable here. Yet, the change to impact-based information provides multiple benefits to practitioners as impact-based forecasts help with the identification and prioritization of areas and communities most severely impacted. This can support a transparent, evidence-based, sector- and context-specific decision-making process directly addressing the communities most in need (IFRC et al., 2023b).
Boult et al. (2022) further argues for an adapting and dynamic impact assessment process, as decadal shifts in climate variabilities, changing exposure and vulnerabilities are not incorporated in a pre-defined system. They propose a hybrid framework of multi-hazard forecasts

interlinked with static vulnerability and dynamically adjusted with real-time expert vulnerability assessments. Threshold triggers are lower, where static vulnerabilities are higher. In order to put predictions into actions, defining thresholds for triggering Anticipatory Action need to accompany the forecast selection procedure.

2.3.3 Trigger Definition

"Triggers are mainly combination of hydro-meteorological forecast combined with exposure and vulnerability data" (RCRC, 2020, p. 19). There are commonly two ways to define a trigger for Anticipatory Actions. On one side, triggers can be consensus-based, meaning experts make real-time judgements by synthesizing information from multiple sources, or on the other side, triggers are data-driven, peer-reviewed and validated well in advance of a potential event (RCRC, 2020). Drought with its different layers of complexity may also benefit from a combination of these mechanisms, as shown by e.g. the proposed dynamic framework of (Boult et al., 2022). Generally, good conditions for effective trigger development are sufficient historical data, knowledge about local livelihoods including how diverse parts of communities are influenced differently, thorough identification of differentiated impact drivers and their correlation to magnitudes as well as trustworthy forecasts (Coughlan de Perez et al., 2015; Coughlan de Perez et al., 2016; Harrowsmith et al., 2020; RCRC, 2020; Stephens et al., 2015).
Furthermore, the framing and definition of the underlying forecast, indices and indicators are paramount as data-driven triggers are "specific values of an indicator or index that initiate and/or terminate each level of a drought plan and associated mitigation and emergency management responses" (Svoboda et al., 2016, p. 13). This specification is highly context specific and e.g. in the case of flood can be defined as the level when the river breaches its banks and inundates the surrounding buildings. Though, in an inanimate area this overflow may only inundate open space and thus lead to no impact at all (Stephens et al., 2015). This circumstance is relatively easy to grasp, has a single trigger and one set of specified actions such as evacuation, transportation and early warning and is therefore well integrable and implementable, see upper illustration in figure 2.6 (Siahaan, 2018).

Drought, due to its slow-onset and potentially cascading impacts that only builds up over time complexifies the process of trigger definition as Anticipatory Actions (AAs) to some impacts may go hand in hand with active responses in some areas and be to early in others. Furthermore, forecast certainty, granularity and accuracy all decrease the more one looks into the future (RCRC, 2020). Deciding when to trigger is therefore a critical and challenging aspect of conceptualizing a drought EAP, see bottom illustration in figure 2.6. Practitioners and experts interviewed by the RCRC (2020) advocate for a staggering triggering system. Here, multiple triggers with different sets of AAs would extend the single trigger mechanism and give the opportunity to account for the different phases and the inherent complexity of the phenomenon drought. Moreover, the RCRC (2020) calls for the development of "unconventional triggers for Forecast based Action (FbA)" (p.30) by "thinking outside the box in terms of both hydro-meteorological and socio-economic indicators" (p.31) as the trigger development is still ongoing, even within the RCRC.

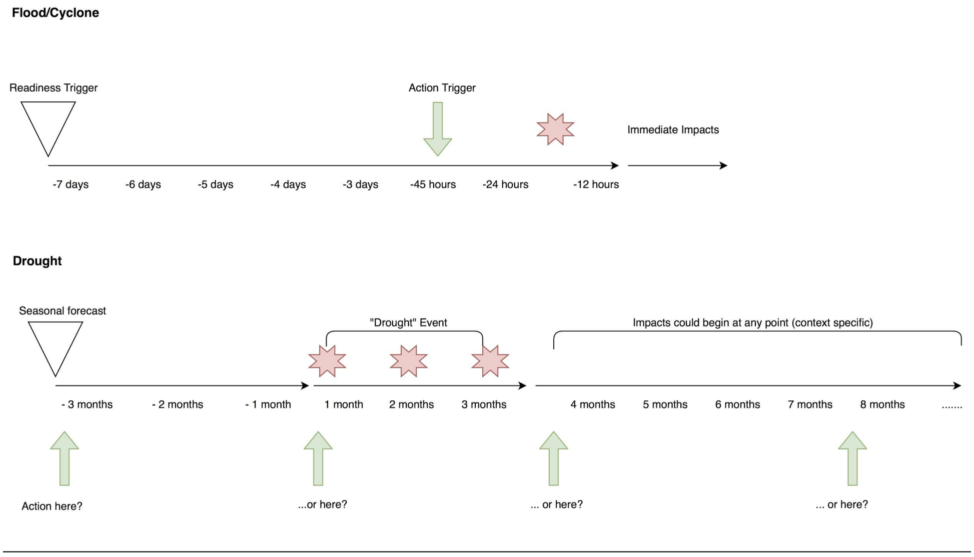

FIGURE 2.6: Time differences between slow- and fast-onset hazards. Source: RCRC (2020)

2.3.4 Anticipatory Actions

Anticipatory Actions are at the heart of every EAP and their execution is what everything else is working towards. The goal of every Anticipatory Action is to support people and communities at risk to reduce negative impacts of a hazard. The final execution is preceded by some conceptual and practical steps. The establishment process begins with the identification of contextually meaningful, suitable and locally realisable actions with special focus on stakeholders, resources and available lead-time. These are further prioritized and selected based on the risk assessment, type and magnitude of hazard, and forecasting capabilities. When a first set of AAs is defined, they are again assessed in detail, reflected and decided on with stakeholders and ultimately finalised. Together with an evaluation phase and the definition of prediction and triggers, it is often a simultaneous and iterative process that does not end with the operationalisation of the EAP (IFRC et al., 2023c, 2023d; RCRC, 2020; Stephens et al., 2015).
In practice, Anticipatory Actions are commonly split into a preparation and an activation phase. The preparation phase builds on the process described above where the conception is outlined, but also extends to preparation activities, such as the prepositioning of water tablets before the rainy season (Stephens et al., 2015). The activation phase requires a constant operation of forecast monitoring and is initiated when the trigger is reached. Timely information dissemination, releasing and receiving funds, implementing of the AAs and subsequent evaluation are part of this phase (IFRC et al., 2023c; Stephens et al., 2015). Often, the actual AAs are not very different from response actions except of their predictive and proactive nature.
However, precisely this foresight has the great advantage that the impact of the disaster can potentially be substantially reduced but also comes with the cost of uncertainty as forecasts may not always be accurate. In the event that a probability threshold is reached, the AAs are triggered and carried out but the disaster does not occur or occurs somewhere else, is generally referred to as *"acting in vain"* (Coughlan de Perez et al., 2015). Besides financial costs, this may

also manifest in reputational costs in e.g. the case of Early Warning and evacuation if false alarms occur too frequently (Stephens et al., 2015). Albeit, a growing body of evidence suggests that the benefits of AAs outweigh the costs substantially (Cabot Venton, 2018; Coughlan de Perez et al., 2015; Gualazzini, 2021). Furthermore, the issue of *acting in vain* can be lessen by staggering triggers and adjusting AAs in accordance with long-term resilience building (WFP et al., 2021). This can either allocate the actions more precisely or increase the general benefits. IFRC et al. (2023d) makes these design adjustments the basis of its definition of *acting in vain* and thus argues for the abolition of this term, since the benefits of acting should always outweigh not acting at all.

2.4 Citizen Science

The inclusion of local knowledge in the system of Early Warning and Anticipatory Action may result in many benefits as already mentioned in the end of chapter 2.2.4. Adapting knowledge and policies to local conditions and people as well as learning from them, strengthening autonomous responses and involving local stakeholders in all stages of the processes are just some of the potential ways to improve implementations (Giordano et al., 2013; IDMP, 2022; Lackstrom et al., 2022; Leal Filho, Barbir, et al., 2022; Leal Filho, Totin, et al., 2022). One way to include local knowledge is through Citizen Science (CS), very broadly defined as "public participation in scientific research and knowledge production" (Fraisl et al., 2022, p. 1).
Historically, the first Citizen Science project was possibly the Christmas Bird Count run by the National Audubon Society in the USA every year since 1900 (Link et al., 2006; Silvertown, 2009). Since around 2000, the number of publications in regard to CS has risen substantially and CS has established itself as a vibrant area of scientific interest (Kirschke et al., 2022). As more and new thematic fields joined this area of interest, numerous approaches have been made to define CS more precisely (Haklay et al., 2021).
Over 30 definitions were selected by Haklay et al. (2021) to explore their ambiguity and extend the best practice principles and characteristics of CS established by the European Citizen Science Association (ESCA, 2015; ESCA et al., 2020). Different political, scientific or societal lenses along with a variety of focal points such as (1) biology, conservation and ecology, (2) geographic data and (3) social sciences and health related issues have all contributed to the concept of Citizen Science (Haklay et al., 2021; Kirschke et al., 2022). The first field of study, natural research and conservation, is the orientation most frequently related to CS with overlapping concepts to community-based, volunteer and participatory monitoring. It has common interests with the second field of Volunteered Geographic Information (VGI) in topics such as crowdsourcing and data quality whereas the third field of study mostly resolves around public engagement with intersections to CS in public participation (Kullenberg & Kasperowski, 2016). Thus, in the still emerging field of Citizen Science, there is already experience in various areas of participatory mapping and monitoring, but not much yet in specific monitoring for risk related anticipatory measures.

In order to highlight the core of CS alongside the different disciplinary orientations of the research, different frameworks, guidelines and levels of participation have been designed and defined. Kirschke et al. (2022) created a three cluster framework of design principles around *citizen* and *institutional* characteristics, together with their *forms of interaction*. Within these clusters Kirschke et al. (2022) highlight various qualities and skills such as age, social status, motivation, knowledge and education of the contributing citizens, financial and human resources on the institutional side as well as the method and density of communication and feedback practices as important parts of interactions. Guidelines and principles further specify, expand and structure these broad topics to make them practically applicable in various contexts (CitizenScience.gov, n.d.; ESCA, 2015; ESCA et al., 2020; eu-citizen.science, n.d.; Fraisl et al., 2022; García et al., 2021; Pocock et al., 2014; Skarlatidou et al., 2019).

Citizen Science projects can also be differentiated according to how engagement with participants is designed. This is referred to as the *levels of participation* and is commonly structured into four levels. Increasing in participation intensity, Buckingham Shum et al. (2012) categorize them into (1) Crowdsourcing, (2) Distributed Intelligence, (3) Participation Science and (4) Extreme Citizen Science. Following this categorization, participants can be (1) 'sensors', (2) 'interpreters', (3) engaged in problem definition and data collection or even (4) part of the analysis.
Depending on the level of participation and thematic orientation, CS is related to concepts of classic monitoring practices (1), transdisciplinary research emphasizing engagement of the public along the entire process (2 & 3) and participation involving "groups that are or perceive themselves as being affected by the decision" (Renn, 2006, p. 1) (3 & 4) (Buckingham Shum et al., 2012; C. C. Conrad & Hilchey, 2011; Minkman, 2015).

Current challenges and limitations in CS projects are the complex demands in the conceptualization and design process with a wide range of required skills and resources. Recruiting participants and sustaining their motivation, data quality and accuracy considerations, biases in collection and analysis as well as privacy regulations are just some important aspects to consider (Fraisl et al., 2022). Nonetheless, numerous studies suggest promising developments and application possibilities addressing most of the above mentioned challenges in design, participant and data related issues (Buckingham Shum et al., 2012; Budde et al., 2017; ESCA et al., 2020; Fraisl et al., 2022; Lowry et al., 2019; Pocock et al., 2014; Rutten et al., 2017; Weeser et al., 2018). However, both research and CS projects are currently unevenly distributed around the world, with an over-representation of North American and European countries, leading to a lack of experience and guidance on other regions and contexts of the world (Kirschke et al., 2022; Zheng et al., 2018).

2.4.1 Community-Based Monitoring (CBM)

Community-based monitoring (CBM) is a sub-concept of citizen science and can be allocated to different layers of participation, depending on its definition, aspects and final implementation (Weston & Conrad, 2015). CBM can encompass "a process where concerned citizens,

government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern" (Whitelaw et al., 2003, p. 410). The focus of CBM on monitoring is fundamental, but the monitored subject, further handling of the data and the involvement of the participants can vary widely (Baptiste et al., 2020; C. C. Conrad & Hilchey, 2011; Khair et al., 2021; Koehler & Koontz, 2008; Shirk et al., 2012; Weston & Conrad, 2015). Within this work, CBM is understood as a combination of two main aspects. The collection part often refers to concepts of *Crowdsourcing* or *Crowdsensing* (see next section 2.4.2) and a management aspect which promotes the incorporation of the generated information into community decision-making processes (C. Conrad, 2007; Keough & Blahna, 2006).
Community-based monitoring can serve many purposes but its implementation and application is not always recommended. Therefore, many guidelines precede the design with an assessment of the feasibility of this approach (CitizenScience.gov, n.d.; ESCA, 2015; Fraisl et al., 2022; Minkman, 2015; Pettibone et al., 2016). Here, the challenges, benefits and capabilities of the CBM approach are compared with the problems and core objectives of the project. It is emphasized that CBM should not be the goal itself, but only a means to fulfil the project goals (Minkman, 2015). Nonetheless, the diversity of this approach means that other goals can be pursued and achieved apart from the main interests. For example, enriching participants by addressing their needs, advancing their knowledge or teaching them new skills is considered as fundamental and important to achieving the main objective as it is to a successful project (Fraisl et al., 2022; Minkman, 2015). In the following, a short overview about challenges, benefits and recommendations of CBM is given, broken down in the design phase, incorporation of participants and data concerns.

The Design of CBM projects on the level of participation or the tripartite division according to characteristics of citizens, institutions and their forms of interaction have already been mentioned in connection with the broader concept of Citizen Science and are also applicable here. More concrete design factors and variables were synthesized by Kirschke et al. (2022) but the systematic understanding of their influences on the success of CS projects remains unclear up until today. A selection of subjects outside of the original research itself could be overall project management, communication in its various forms and with all stakeholders, community and participant recruitment, participant training and management, data management and analysis as well as the final implementation and operation of the project. Moreover, there is agreement that no *one-size-fits-all* solution exists and different goals, resources, and contexts have considerable influence on the design from project to project (Fraisl et al., 2022). In order to account for the variety of challenges and to maximize the benefits, staged frameworks have been developed to guide the design (CitizenScience.gov, n.d.; Fraisl et al., 2022; García et al., 2021; Minkman, 2015). Yet, these frameworks can be relatively coarse and imprecise and are often partly tailored to specific goals and contexts, making a combination of several such frameworks and the inclusion of further guidelines and recommendations potentially necessary to tailor the design to the specific situation. **Participants** can take many roles in a CBM project based on the level of participation chosen. Regardless of this, their adequate integration is seen as a cornerstone of any CBM project (Land-Zandstra et al., 2021). Knowledge and skills as well as other socio-economic variables can vary widely between participants and it is important to account for this to inspire and keep participants motivated to contribute (Minkman, 2015; Whitelaw et al., 2003). One mayor drawback of online collaborative initiatives is often that a considerable proportion of contributors only participate once and with minimal effort while a relatively small number of participants are responsible for the majority of the work (Sauermann & Franzoni, 2015). Understanding and thus sustaining the motivation of participants is therefore central to a successful project. The subject of what drives individuals to participate in citizen science projects has been extensively explored in literature (Land-Zandstra et al., 2021; Minkman, 2015; Mloza-Banda & Scholtz, 2018; Rutten et al., 2017; Tipaldo & Allamano, 2017; D. W. Walker et al., 2021). Motivation can be intrinsic or extrinsic and spans from the will to contribute to science and conservation over meeting and helping other potentially like minded people to learning new skills and financial compensation (Minkman, 2015; Rotman et al., 2012; Rutten et al., 2017). According to Rotman et al. (2012)'s study, egocentric motives tended to drive new participants, whereas established participants were more motivated by altruistic reasons, such as helping others. Furthermore, the individual adaptation of the task's difficulty to each participant was suggested to positively influence motivation in order to neither bore nor overwhelm (Minkman, 2015). Other factors to inspire and sustain motivations are, among others, the expected benefits, acknowledgement and feedback culture and its perceived usefulness and integration into further processes (Land-Zandstra et al., 2021; Minkman, 2015; Pettibone et al., 2016). In addition to strengthening motivation, breaking down barriers to participation can also prove helpful. For this, understanding the background and circumstances of the participants is important. In their work for hydrological monitoring in Kenya, Weeser et al. (2018) could partly attribute low participation rates to the transmitting costs of 0.01 USD per text message at some station. Offsetting these costs could subsequently increase the overall participation rate. Weeser et al. (2018) further discovered, that actual compensation or incentives appeared unnecessary as the intrinsic motivation of the participants proved to be adequate once financial constraints were addressed. Besides financial and resource restrictions, lack of knowledge and skills can be addressed by providing adequate training (Fraisl et al., 2022; Lackstrom et al., 2022).

Data Management and common data quality concerns can also be addressed through supervision, external or mutual feedback and preceding training of participants (Albus et al., 2020; Baalbaki et al., 2019; Fraisl et al., 2022). Besides the characteristics of the participant, the difficulty of the measurement task itself influences the quality. Simpler tasks such as gauging water levels provided high data quality in Weeser et al. (2018) study. Baalbaki et al. (2019) has further found that most of the data collected by citizen scientists is comparable to that of university scientists when it comes to chemical or physical qualities of water. (Albus et al., 2020) could support this finding, by analysing data from the Texas Stream Team (TST) citizen science program and found an agreement of 80% up to 90% for DO, pH and conductivity parameters. However, Baalbaki et al. (2019) also noted a disparity in the bacteriological test results between citizen and university scientists, to which they remarked, that it may be explained by the complexity of the testing process and the quality of the testing materials employed. Aceves-Bueno et al. (2015) evaluated over 80 peer-reviewed studies of which only 11% reported no data accuracy issues but only one study reported, that the data was unusable. Based on the aforementioned findings, ensuring data quality and accuracy through appropriate quality assurance and control measures is crucial. However, despite the reliability and accuracy challenges associated with CBM data, Aceves-Bueno et al. (2015) noted, that these issues typically do not have a significant impact on the data's overall usefulness.

Besides the more specific challenges and benefits mentioned above, Community-based monitoring approaches can benefit scientists, decision-makers, communities and participants in multiple ways. In addition to achieving the main objectives, raising awareness of the issue, the needs and the problems at hand, as well as increasing knowledge among all project stakeholders, can lead to changes in behaviour, improved management, reduced risks and a better representation of local conditions in the regional, national and international context (Huang et al., 2020; D. W. Walker et al., 2021). Output quality can be enhanced when the objective is clear, participant involvement is recognized as a high priority, enough resources for design, implementation, operation and analysis are available and the monitoring protocol is not too complex (Butte et al., 2022; Pocock et al., 2014).
In an attempt to scale this concept across regions or even an entire country with many physical, social and economic differences, the CBM concept has been increasingly explored with mobile, network-enabled devices. This is, together with practical examples and projects, presented in the coming sections.

2.4.2 Mobile Crowdsensing (MCS)

Crowdsourcing originated in 2006 from an article by Jeff Howe and Mark Robinson describing crowdsourcing as a new internet based business model in the terms of "It's not outsourcing; it's crowdsourcing" (Howe, 2006), by harnessing "the creative solutions of a distributed network of individuals through what amounts to an open call for proposals" (Brabham, 2008, p. 76). Due to the merely perceiving and transferring and not further interpreting character, *Crowdsourcing* is on the lower levels of participation. A more specific form of *Crowdsourcing* is *Crowdsensing* which refers to the process of measuring and collecting data by a large mass of contributors that involves using mobile devices and sensors to collect information about the environment. This is also known as Mobile Crowdsensing (MCS) (Guo et al., 2014; Liu et al., 2018).
MCS is part of a widespread transition in the way data is gathered and managed, with a shift away from conventional methods towards incorporating mobile devices, web platforms, and apps (Capponi et al., 2019; San Llorente Capdevila et al., 2020). This transition is being driven by the development and proliferation of information technology infrastructure, which includes the collection, sharing, storage, cleaning and analysis of data (Fraisl et al., 2022). These components of the information technology infrastructure can be grouped into a four-layer architecture which is described in detail in the paper by (Capponi et al., 2019). The first and top

layer is the *application layer* concerned about high-level user, task- and overall design and organizational aspects with some examples being user recruitment's, scheduling and contribution management. The *data layer* as the second layer refers to storage, processing and analysis of the received data and is followed by the *communication layer* which refers to methodological and technological aspects of the reporting characteristics. These include cellular, internet or other networks and their means of transmission. The bottom layer, the centrepiece of this architecture, is the *sensing layer* which includes all tools, technologies and equipment involved in the data acquisition process (Capponi et al., 2019). Measurements can be of different types, intentional or unintentional, at the occurrence of an event or continuous, and are based on human observation, instrumental measurements or a combination of both (Zheng et al., 2018). In this architecture hierarchy, data flows generally from the lowest to the highest layer (Aceves-Bueno et al., 2015; Capponi et al., 2019; Zheng et al., 2018).

Besides generally applicable challenges of Community-based monitoring such as data quality and participant motivation, main challenges of MCS are seen in the socio-technical, privacy and security realms referring to hard- and software availability, reliability and usability as well as balancing access rights, anonymisation and encoding with data trustworthiness (Aceves-Bueno et al., 2015; Alfonso & Jonoski, 2012; Capponi et al., 2019; Liu et al., 2018; Minkman, 2015; Noureen & Asif, 2017). Nonetheless, MCS also provides many opportunities and solutions to designers, operators and participants alike. Among those are the relatively good and easy scalability and increase of monitoring network density, low barriers for participation and two-way communication options as well as high potential for automatization and interoperability with other applications and frameworks (Alfonso & Jonoski, 2012; Minkman, 2015; San Llorente Capdevila et al., 2020; Weeser et al., 2018). In the following, practical examples of CBM and MCS or a combination of both are presented, highlighting the wide-ranging application possibilities.

2.4.3 Examples of CBM and MCS

The potential applications for MCS, embedded in CBM or as a stand-alone project, are, as for all Citizen Science, wide-ranging and diverse. Besides the thematic diversity, the socio-technical implementation, size and complexity can differ substantially from project to project. Established networks like the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) founded in 1998 USA with nowadays over 25.000 observers facilitate the collection of daily weather observations and the sharing of written impact impressions via an online platform (CoCoRaHS, 2023; Lackstrom et al., 2022). The Audubon's Christmas Bird Count (CBC) even goes back to the December of 1900 and in its 120th anniversary year over 81.000 observers counted more than 30 million individual birds (LeBaron & National Audubon Society, 2022). Another major project in the realm of crowdsourcing and MCS is the 2004 founded OpenStreetMap Foundation. Started as a reaction to the failed release of geographic information in the United Kingdom, OSM as a collaborative community effort quickly became one of the most important sources of geographic information world wide (Bennett, 2010; contributors, n.d.). Additional contemporary developments include the concept of MCS in citizen participation, Smart Cities, resource management, transport and behaviour evaluation and many more (Commission, 2021; DIPAS, 2023; H. Wang, 2022). Other projects with a thematic focus on health, water and early warning are considered in more detail in the remaining part of this section.

Health, as Community-based Surveillance (CBS) is successfully implemented as CBM with NYSS as MCS platform in Somalia as it is the only really locally comparable project to which the otherwise North America and Europe-centred and technically more sophisticated projects can be set in relation. Community-based Water Monitoring (CBWM) and Community-based Disaster Risk Reduction (CBDRR) projects,as their thematic guidance can be transferred to this work. Projects concerning VGI will not be discussed in depth in this context, as mapping in this project will most definitely be carried out by professional and trained personnel.

Community-based Surveillance

Conventional surveillance systems for monitoring health of animals, humans and the environment rely on information of medical professionals, health facility records, and laboratory examinations to detect abnormalities that could signify potential outbreaks and newly emerging pathogens (McNeil et al., 2022). However, these data are not sufficiently accessible in all regions of the world to allow adequate responses (McNeil et al., 2022; Nikolay et al., 2017). The strong developments and increasing availability of mobile technologies, the recognition of the value of local knowledge in health management, and recently reinforced by the COVID 19 pandemic, have led to an an increasingly widespread use of CBS (Kullenberg & Kasperowski, 2016; McNeil et al., 2022). The Technical Contributors to the June 2018 WHO meeting (2019) defined CBS as "the systematic detection and reporting of events of public health significance within a community by community members" (p.1). With the growing importance of the *One Health* approach, these "events of public health significance" (CDC, 2022b) span across the domains of human, animal and ecosystem health.

McNeil et al. (2022) identified 60 different ongoing surveillance systems across five continents. These systems were covering the three domains either stand-alone or in combination, on different spatial scales and with different technical characteristics. However, all projects have used some kind of digital technology, with websites and smartphones as the most common vehicles. Furthermore, a high percentage of the surveyed projects have noted the usefulness of the CBS approach as it "improved community knowledge and understanding" (p.1) (78%) and "earlier detection" (p.1) (67%) (McNeil et al., 2022). This finding is supported by various other studies (Byrne & Nichol, 2020; Jarrett et al., 2020; McGowan et al., 2022; Metuge et al., 2021; Ratnayake, Finger, et al., 2020; Ratnayake, Tammaro, et al., 2020; Technical Contributors to the June 2018 WHO meeting, 2019).

The CBS approach has proven to be a more advantageous complement to the conventional system, especially when certain conditions are taken into account. Guenin et al. (2022) highlights the importance of congruent definitions and their adaptation to the different actors and roles as well as the adaptation of (two-way) communication channels. Preceding suitability assessments, simple design and reasonable incorporation of technology, effective community engagement, reliable and close surveillance through supervisors of local volunteers especially in the beginning as well as evaluation and feedback opportunities have been highlighted as key drivers for success. These drivers were grouped by McGowan et al. (2022) in relation to (1) surveillance workers, (2) the community, (3) case detection and reporting, and (4) integration. Most of these factors and more have already been mentioned in the CBM context. They were linked to having a decisive influence on the quality of embeddedness in existing systems, acceptance, trust and ultimately its implementation in decision-making and response. In addition to these key success factors, main challenges remain in ethical and privacy considerations, availability of resources and fast response capacities in case of an event as well as community expectation management. Furthermore, Boetzelaer et al. (2020) findings indicate that the additional benefits of CBS in already stable settings are limited as the approach is resource intensive. Nevertheless, in low-resource or conflict-affected areas, where the full range of benefits can be brought to bear, the use of CBS can be of particular advantage. CBS showed promising capacities to address current gaps in health related information, early warning capabilities and response management, especially in regard to spatial coverage and lower response times (Metuge et al., 2021; Ratnayake, Tammaro, et al., 2020). Metuge et al. (2021) has additionally been able to fruitfully adapt CBS for related issues such as displacement and malnutrition and the SRCS is currently using CBS together with the MCS platform NYSS from the Norwegian Red Cross (NRC) in Somalia.

NYSS is an open-source implementation following the MCS concept and is primarily developed by the NRC (Jung et al., 2022). The platform allows for high degrees of automatization in regard to data collection, storage, validation and analysis as well as feedback and notification possibilities.

In regard to law, privacy and data security, NYSS servers are located in Ireland and are therefore under European Union data protection law. Besides these law requirements, NYSS has conducted a Data Protection Impact Assessment (DPIA) in 2020 which has generally attested to good standards and made some recommendations for further improvement (Quinn et al., 2020). Additionally, Quinn et al. (2020) highlighted that the "DPIA is an ongoing process" (p.57) which needs to be conducted regularly which goes in line with the general recommendations for CS evaluation practices. The NRC further conducted a recent evaluation of CBS and NYSS, but the report was not yet published at the time of writing.

While NYSS is developed and operated by the NRC, the data and most of the operations processing of personal user data is owned, overseen and controlled by the respective National Society. However, no personal data is collected, stored and processed in NYSS, with the exception of the volunteer's telephone number and usual place of residence (NRC & IFRC, 2021).

The aim of developing NYSS was to provide a simple data collection tool for early warning, rapid reporting and fast response specifically for health related issues and not for larger data collection endeavours for e.g. the collection of forecast related ground truth data. The current CBS data collection and transmission functions via simple SMS and pre-defined codes. Thus, the collection is limited to these codes and their respective meaning. Nonetheless, due to this restriction to simple coded SMS, a normal phone and mobile network are sufficient for data collection. A smartphone and internet connection is not necessary. The codes have a specific order and are separated by '#'. In a single report, the code in the context of CBS consists of

$$\#health\,risk/event\#sex\#age$$

where the health risk is represented by one number, sex is either male (1) or female (2) and age is categorized into 0-4 years (1) or 5 years and older (2). Aggregated reports are used in case of higher numbers and represent "a summary of several cases" (NRC & IFRC, 2021, p. 35). Here, the order is decisive for the kind of information and the number represents the actual number of cases. The correctness of the code is automatically checked by the system and a feedback message is sent, also giving advice on how to react in regard to the specific disease, sex and age. The subsequent processing and potential escalation of the report can be seen in figure 2.7.

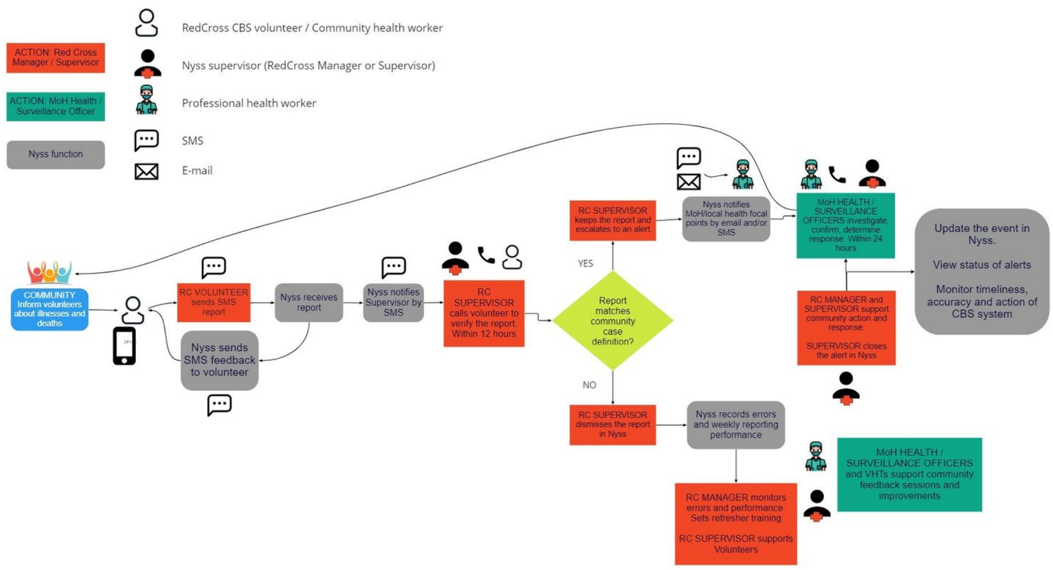

FIGURE 2.7: Sequence Diagram of NYSS. Source: NRC and IFRC (2023)

This representation also shows the close involvement in regional processes for response purposes and the implementation of evaluation and supervision processes in the overall structure. A dashboard with map and table views, displaying data collectors and messages allows further supervision. Fast and simple escalation of warnings to health officials and other organizations is facilitated through their close integration into the platform (NRC & IFRC, 2021, 2023). This high level of automation and good integration into existing organisational structures and actor networks enables rapid responses, often in less than 24 hours (Jung et al., 2022).
Technically, NYSS is primarily coded in C# and JavaScript and based on a Microsoft Azure storage solution. The SMS are received via a physical SMS gateway and asynchronously processed by an internal bus communication system. The receiving functions are structurally separated from the reporting functions and connected via internal API requests. The parsing and validation takes place in the internal ReportAPI and the feedback SMS is sent via a data collector

forwarding the messages to an email-to-sms service which sends the information back to the volunteer (NRC, 2023; NRC & IFRC, 2021, 2023). The source code, along with the documentation, is open source and available on GitHub (NYSS and its infrastructure and architecture documentation).

Community-based Water Monitoring and Management

Community-based Water Monitoring (CBWM) is an application example of CBM which gained mayor public interest particularly in North America, Europe, Australia and Southeast Asia (Canada et al., 2018; Kirschke et al., 2022; Koehler & Koontz, 2008). CBWM practices range from small monitoring projects to integrated partnerships or councils for the management of watersheds (Weston & Conrad, 2015). Just as for CBM and CBS, participant engagement, data quality control and management, sustainable funding and embedding in existing structures are key to successful integration and implementation of such projects (Allen, 2018; Canada, 2018; Weston & Conrad, 2015). An overview of primarily water and weather related citizen science projects can be seen in table 2.1. Striking is the already mentioned globally unequal distribution of the projects with a strong emphasis on North American Countries. Furthermore, their focus is mostly on river, lake, groundwater and precipitation levels or focusses on their respective water quality.

Further noticeable are the technical requirements, which almost always require some sort of smartphone, dedicated measurement equipment or internet access. Only Weeser et al.'s 2018 approach is based on simple text messages but were limited in content to a station ID and the indicated stream water level. Here, signs explaining the monitoring and transmission process with pictures and instructions in Swahili and English were placed next to a water level indicator, encouraging passers-by to contribute (Weeser et al., 2018). Weeser et al. (2018) noted, that the method of "transmitting the observations using simple cell phones and text messages turned out to be stable and reliable without major technical problems" (p.1587) in the context of their work in low-income rural areas in Kenya. The problem of occasionally insufficient network coverage was overcome by participants waiting until they reached a network before transmitting, making network availability not a limiting factor in this study. (Wilson-Jones & Rivett, 2012) established and evaluated an Android mobile based system to support rural water quality monitoring in South Africa by simplifying connection between managers and operators of municipal test facilities. All municipalities expressed the system as beneficial exemplifying the usefulness of fast, easy and low resource-intensive communication possibilities in such a context.

Drawing on their literature review of water quality studies under climate change, Huang et al. (2020) recommend the application of a "hybrid modality in which community management is the mainstay with supplement from external support" (p.147) also considering differences in local realities and stakeholder opinions and needs. One approach to embed CBWM into local traditional community water management practices is proposed by (Day, 2009). Day (2009) argues, that overarching concepts like the Integrated Water Resource Management (IWRM)

TABLE 2.1: Selection of compared Citizen Science projects. Source: Own representation

Name	Country	Interest	Requirements	source
CreekWatch	Canada	Environmental monitoring, water quality	Internet access, Iphone applicaton	(S. Kim et al., 2011)
CoCoRaHS	USA & Canada	Precipitation, condition, drought monitoring	Internet access, local knowledge, measurement equipments	(Lackstrom et al., 2022)
Texas Stream Team (TST)	USA	Environmental monitoring, water quality	Measurement equipment	(Lopez, 2021)
Smart Water Crowdsensing Project	USA	Groundwater monitoring	Internet access, measurement equipment	(Speir et al., 2022)
Social.Water	USA	Hydrologic measurements	Mobile phones	(Fienen & Lowry, 2012)
CrowdHydrology	USA	Hydrologic monitoring	Mobile phones	(Lowry et al., 2019)
Cooperative Observer Program	USA	Weather and climate observations	Mobile phones, Internet access	(Lawrimore et al., 2020)
Haltwhistle Burn Citizen Science	UK	Water, Environmental risks	Internet access	(Starkey et al., 2017)
CS in Water Quality Monitoring	Netherlands	Water quality monitoring	Measurement equipment	(Minkman, 2015)
MAppERS	Denmark	Flood risk monitoring	Internet access, Android application	(Frigerio et al., 2018)
SIMILE APP	Italy	Lake water quality monitoring	Internet accesss, mobile phones	(Carrion et al., 2020)
Citizen science in Kenya	Kenya	Hydrological monitoring	Mobile phone	(Weeser et al., 2018)
ITIKI	Sub-Saharan Africa	Drought prediction, early warning	Mobile phone app, wireless sensors, gauging stations	(Masinde & Bagula, 2012)
Smartphone-based System for water quality analysis	Rajasthan, India	Water quality monitoring	Smartphone, Measurement equipment	(S. Srivastava et al., 2018)
Ushahidi	worldwide	Disaster Management	Mobile phone, backend self service	(Ushahidi, n.d.)
Sahana Eden	worldwide	Disaster Management	Internet access, self-hosted	(Sahana Foundation, 2016)

remain to large and complex to be manageable and implementable on local levels and additionally often fail to adequately include local stakeholders. Building on the decentralized and locally better operationalisable version of IWRM called 'light IWRM' (Butterworth et al., 2010; Moriarty et al., 2004) and its practical component of Water safety plans (WSP) (Bartram, 2009), Day (2009) created a community-based water resource management framework, see figure 2.8.

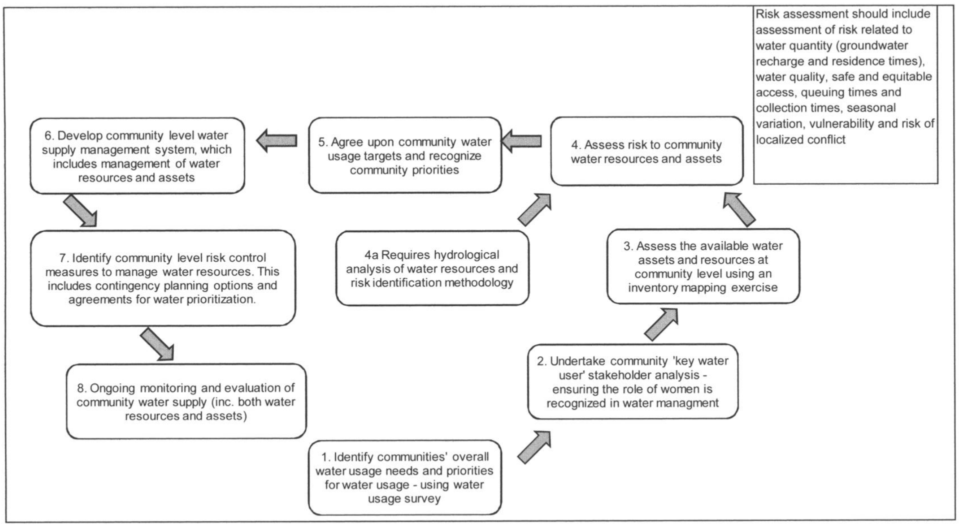

FIGURE 2.8: Community-based Water Resource Management.
Source: Day (2009)

This framework provides the foundation for monitoring by encompassing the specifics of arid regions also with regard to possible drought phases, community needs, risks and water resource assets. Furthermore, the community is seen primarily as a partner rather than a beneficiary and also takes internal communal heterogeneity and inequalities into account, making it a good conceptual basis for this works water source monitoring design approach. The general usefulness and practical applicability of this framework is indicated by (Oxfam, 2009), as they make this framework the basis of their community-based water resource management implementation guide for field programmes in dryland areas. Further work for guiding principles in the sphere of CBWM are numerous and interested readers are referred to (Weston & Conrad, 2015).

Further Community-Based Concepts and Initiatives

Potential capabilities and areas of application to apply the concept of CBM and MCS are wide-ranging and numerous. Besides health- and water related domains, Community-based Disaster Risk Reduction (CBDRR), Disaster Risk Management (CBDRM), Early Warning Systems (CBEWS) are rising fields of application. While health and water-related projects can be part of the broader CBDRR or CBDRM approach, depending on their focus, many projects about CBDRR, CBDRM and CBEWS focus on natural disasters such as droughts, fires, typhoons, (flash) floods, and landslides (Macherera & Chimbari, 2016; Manalo, 2013; Pineda, 2015; Smith et al., 2017; Tarchiani et al., 2020; Trogrlić & van den Homberg, 2018; Vhumbunu, 2021). Based on

UNISDR (2009), Vhumbunu (2021) defines CBDRM as "the involvement of potentially affected communities in disaster risk management at the local level by building their capacities to assess their vulnerability to natural disasters and develop strategies necessary to mitigate the impact of these disasters" (p.198) and further states, that "at the core of these concepts is the involvement of communities in making decisions and implementing disaster risk management strategies, actions, and initiatives" (p.198).
Examples for participatory Disaster Management Software are large and multi-purpose platforms like Ushahidi, Sahana Eden and Kobo (Kobo Organization, n.d.; Sahana Foundation, 2016; Ushahidi, n.d.). A smaller but dedicated approach to bridge indigenous knowledge and modern science by disseminating early drought information and warnings is the ITIKI (Information Technology and Indigenous Knowledge with Intelligence) framework currently under development and evaluation in Kenya, Mozambique and South Africa (Akanbi & Masinde, 2018; Masinde, 2014; Masinde & Bagula, 2010, 2012; Masinde & Thothela, 2019; Masinde et al., 2013, 2018; Nyetanyane & Masinde, 2020; Thothela et al., 2021). This system integrates scientific and indigenous drought forecasts by combining local and expert knowledge, technical components like wireless sensors, mobile phones and artificial intelligence analysis capacities to provide micro-level forecasts to local farmers and communities. Positive effects of local drought forecast dissemination could also be confirmed by Andersson et al. (2020)'s study while also mentioning, that local capacities or pre-conditions often limited a positive respond to the early warning.
Gladfelter (2018) and Inayath (2018) and Trogrlić and van den Homberg (2018) highlight the importance to tailor the information to the needs, capacities and social structures of communities on the ground to enable their successful implementation. Accounting for community heterogeneity is also emphasized by Gladfelter (2018) as specific people or groups may be incapable to respond to early warnings due to a lack or resources or knowledge. In addition, (Inayath, 2018) advocates that early warning messages should be "simple, timely, and encourage early action" (p.21) to enable an appropriate response in the first place.

Another problem in implementing participatory early warning systems is the gap between classical top-down approaches and community-based bottom-up initiatives. Successfully bridging the gap between these two approaches by directly coordinating available technical capacities through a participatory approach is possible according to Tarchiani et al. (2020). This is supported by Henriksen et al. (2018) findings, that bottom-up approaches in contrast to classical concepts better facilitate the integration of local stakeholders in processes of decision-making and risk management. Generally, Marchezini et al. (2018) literature review indicates a shortage of research in regard to Citizen Science and CBEWS and Baudoin et al. (2014) additionally notes the need to significantly improve the design and application of early warning systems. Baudoin et al. (2014) advocates for an integrated cross-scale approach ensuring the involvement of the at-risk population at all stages of the management process. Further arguing for "early warning systems that are both technically systematic and people-centred" (Baudoin et al., 2014, p. 15). The concept of CS thus fits well with the theme of risk-based monitoring, but has so far been hampered by little research.

The CBS approach along with the MCS NYSS application has thus shown that CBM and MCS can be successfully applied in the local context. CBWM and CBDRR approaches have further demonstrated the potential adaptability of CBM and MCS to water monitoring and risk reduction issues. More on the regional implementation in sections 2.5.5 and 4.3.5.

2.5 Case Study Somaliland

Northern Somalia, also known as Somaliland, is a region located in the Horn of Africa. The self-proclaimed Republic of Somaliland is an independent, de facto sovereign state, but it is not recognised internationally and continues to be considered part of Somalia. Somaliland is bordered by the Gulf of Aden to the north, the Puntland region to the east, the Federal Republic of Ethiopia to the south and west, and the Republic of Djibouti to the northwest. The claimed region encompasses around 177,000 km^2 and has an estimated population size between 4.2 to 5.5 million people, depending on the calculation and source (Petrucci, 2022; Republic of Somalia, 2021; SCRS, 2022). Administratively, Somaliland is divided into five regions according to internationally recognised regulations, from east to west and from north to south: Awdal, Woqooyi Galbeed, Todgheer, Sanaag and Sool with the capital Hargeisa in Woqooyi Galbeed, see figure 2.9 (Republic of Somalia, 2021). Somaliland's own constitution divides the country into 6 regions where Woqooyi Galbeed is further divided into Maroodijeex (Hargeisa region) and Sahil (Republic of Somaliland, 2019).

This chapter will give a brief overview about the geography, economy and social conditions. It will place the above concepts in the context of past and present local conditions and elaborate on current work on early warning concepts and projects.

2.5.1 Geography & Climate

The geography of this region is marked by its arid and semi-arid conditions, with a diverse range of physical and environmental features that define its landscape. Topographically, Somaliland can be divided into three main zones: the coastal plain *Guban*, the mountain range *Oogo* and the plateau *Hawd* (Republic of Somalia, 2021). The *Guban* (Somali for 'the burnt') area is a very hot and arid region averaging less than 100 mm rainfall per year with potential evapotranspiration exceeding rainfall by thirty times (Salem, 2016). Furthermore, it is not unusual to have no rain at all for 2-3 consecutive years. The *Oogo* mountain ranges receive up to 500-600 mm of rainfall annually with equal evapotranspiration potential, and annual mean temperatures of 20-24 °C, with peaks rarely exceeding 35 °C. Temperature conditions on the *Hawd* plateaus are comparable, but precipitation can be lower and the potential evapotranspiration is at a factor of about 1.5 (Abdulkadir, 2017; Salem, 2016).
Somaliland's climate is typically arid to semi-arid and experiences four distinct seasons. The primary rainy season, known as *Gu'*, takes place from April to June and contributes to about 50-60 % of the annual precipitation. The secondary rainy season, called *Dayr*, lasts from August to November and accounts for approximately 20-30 % of the total rainfall. The remaining two seasons are *Jiilaal* and *Xagaa*, which occur from December to March and July to August,

respectively, and are characterized by dry conditions (Abdulkadir, 2017; Republic of Somalia, 2021).

A detailed description of the geological features of Somaliland, together with many pictorial impressions can be found in (Petrucci, 2022). The soil types in Somaliland are closely linked to its geomorphology and are typically marked by poor structure, high permeability, low capacity to retain moisture, and insufficient internal drainage (Salem, 2016). The naturally sparse vegetation, tree cutting and overgrazing also lead to accelerated soil erosion (Salem, 2016). Nomadic and transhumance pastoralism activities influence around 90 %, and agro-pastoralism about 2 % of the land with often adverse environmental effects (Salem, 2016). Besides poor soils, high levels of erosion, a challenging climate, and little water resources stress the local fauna, flora and human population.

2.5.2 Water Sources

Often insufficient knowledge about hydrogeological conditions and access depths of more than 100 m caused a rather limited number of boreholes in Somaliland, see section 4.3.1 (FAOSWALIM, 2012; Petrucci, 2022; Salem, 2016). As there are no permanent rivers in Somaliland, the use of surface water is primarily based on water retention structures to store part of the precipitation

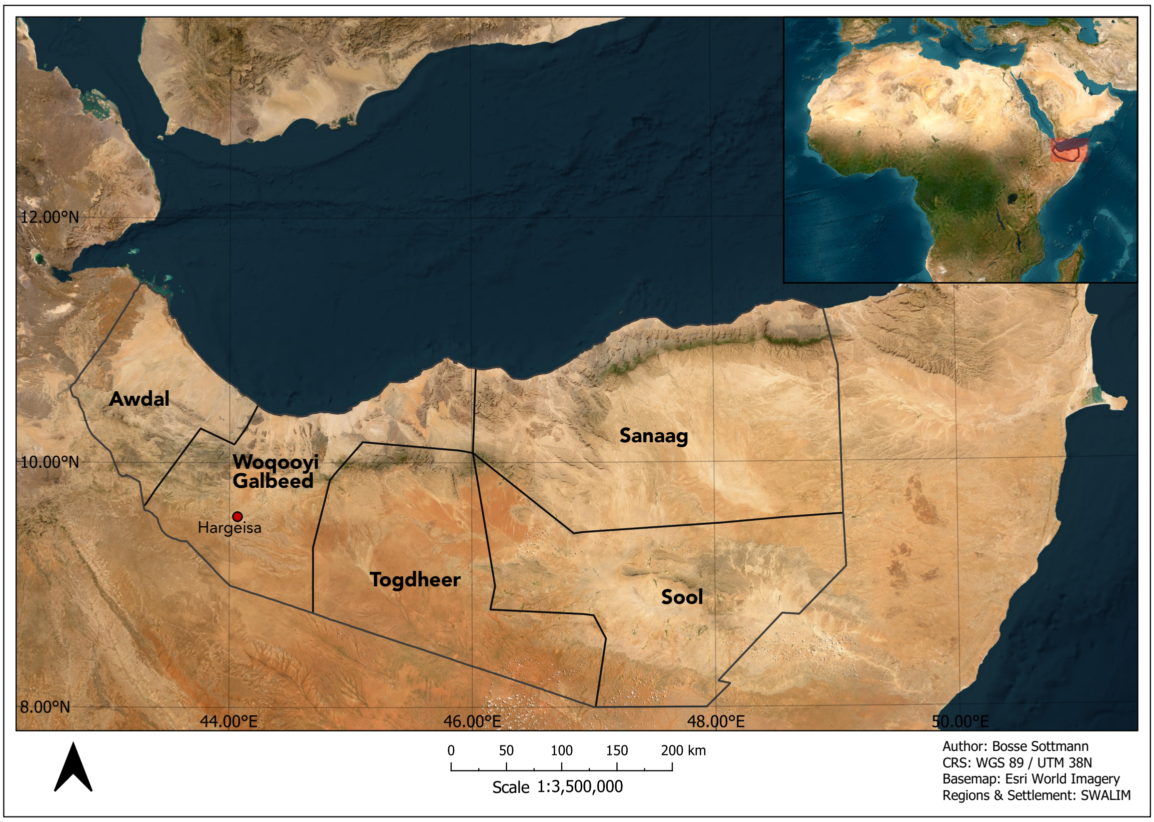

FIGURE 2.9: Internationally recognized Regions of Somaliland. Source: Own representation. Basemap: Esri et al. (2023), Regions: SWALIM (2019) & Settlement: SWALIM (2016), CRS: WGS 84 / UTM zone 38N.

water supply beyond the rainy season (Petrucci, 2022). Wide and open structures called *balleys* can store large volumes of water, but do not last as long as *berkads*.

(A) Unimproved Berkad. Source: Mafuta et al. (2021, p. 5)
(B) Open improved Berkad. Source: LIFE (2017)
(C) Improved Berkad. Source: The Pharo Foundation (2020)

FIGURE 2.10: Different Construction Methods of Berkads.

Traditional berkads are commonly 3 to 4 meters deep, 7 to 9 meters wide and 10 to 13 meters in length. Build materials are commonly stones and clay and some are covered with organic materials such as sticks and bushes, see figure 2.10. Berkads are generally constructed in clusters and usually built on a slope to collect water during the rainy season, but are sometimes filled by man-made canals with or without impurity collection facilities (R. Walker & Sugule, 1998). Missing prevention mechanisms during the filling process can result in contamination of the water with organic matter, animal or human faeces et cetera (Mercy Corps, 2017). The lack of separation between animals and people can also lead to contamination during water extraction. Improved designs are available, and more sophisticated versions nowadays use concrete, are properly roofed to counteract evaporation and pollution, and have adequate inflow and outflow mechanisms to prevent contamination (Mercy Corps, 2017; Petrucci, 2022). Following (Mercy Corps, 2017) calculations, an improved berkad needs to have a volume of about 1000 to 1200 cubic meters to withstand a 3 month dry period with a monthly extraction of 288 m^3. This amount would serve 240 persons (20l/day/person), 150 camels (12l/day/camel) and approximately 2000 (1.5l/day/animal) sheep and goats. Currently valid total number of Berkads for Somaliland do not exist but (R. Walker & Sugule, 1998) estimated about 12.000 berkads clustered in 126 groups in the ethiopian district in Gashaamo, which borders Somaliland in the south. (Birch, 2008) notes 7000 berkads for the Hawd region. Although both with an unknown number of non-operational berkads, the sheer number and reliance of pastoralists and communities on berkads mentioned by (R. Walker & Sugule, 1998) and (Birch, 2008) illustrate their importance. Besides boreholes and berkads, shallow wells, springs and dams are types of water sources. Available datasets about all water sources but especially berkads, concerning e.g. their location, functionality, status of ownership and other factors partly contradict each other, are limited, mostly outdated and unknown in quality, see section 4.3.1(SWALIM, n.d.).

2.5.3 Political & Social Affairs

After being ruled by the Ottoman Empire and subsequent British colonisation, Somaliland gained independence on 26th June 1960. A few days later Somaliland voluntarily merged with

Italian Somalia to form the Somali Republic. From 1969 until 1991, Somali Republic was controlled by a military junta, led by Siyad Barre who, from a supremacy of the southern part, cruelly and partly arbitrarily suppressed the northern one, Somaliland. Arrests, mine water points and executions culminated in the genocide of thousands of members of the largest clan, the Isaaq tribe (Peifer, 2009; Republic of Somalia, 2021). Since the collapse of the Siad Barre regime in 1991, Somaliland has developed into one of the most politically stable democracies in the Horn of Africa, but is challenged in recent times due to the postponement of elections (BBC, 2022; Forti, 2011). Though, internal conflicts and border disputes with Puntland in the east continue until today (Filho & Motta, 2021). Nowadays, Somaliland is a presidential republic, combining its traditional clan culture with modern democratic elements and structures of the House of Representatives and House of Elders (Salem, 2016).
Somaliland has a GDP of approx. 1.5-2$ billion, mostly based on remittances from Somalilanders working abroad and with the main export being livestock, per capita income is only in the hundreds of dollars (Klobucista, 2018; Republic of Somalia, 2021; World Bank, 2014). Low literacy rates (˜48% for adults above 15), a 35% secondary school education completion rate and high unemployment rates further complicate the situation (Republic of Somalia, 2021; World Bank, 2014). Due to its reliance on pastoralism and livestock for mayor parts of its economy and food security, Somaliland is prone to natural disasters (USAID, 2018).

2.5.4 Hazards & Risks

Drought, flash floods, land degradation and conflict all pose risks to Somaliland's environment and society, with droughts posing the greatest threat in recent times (Abdulkadir, 2017). Several historical and current analyses and predictions indicate, that these phenomena will not decrease but possibly intensify and become more frequent driven by large phenomena like the El Niño-Southern Oscillation and rising Sea Surface Temperatures (SST) (Abdulkadir, 2017; Ali & Jemal, 2017; Balint et al., 2013; Erian et al., 2021; FAO SWALIM, n.d.; Musei et al., 2021; National Drought Committee, 2022; Trisos et al., 2022). Population growth, deforestation and desertification, groundwater depletion and land grabbing further stresses the situation (Ali & Jemal, 2017). While a rough tendency can be derived from such predictions, Abdulkadir (2017) findings indicate, that the forecast quality of global climate model simulations "show varying results and therefore remain uncertain for Somaliland" (p.10).
Geographically, the eastern regions Sanaag, Sool and Todgheer are historically the most severely impacted ones (Abdulkadir, 2017; FAO SWALIM, n.d.). In the period since 1960, Somaliland experienced 17 major droughts with the most intense and widespread droughts in 1973-1974, 1984, 1991, 2010-2012, 2016/2017 and 2021 until today (Abdulkadir, 2017; CRED, 2023). The worst drought in 2010-2012 led to a famine, where more than 200.000 people died and over 2.6 million people were affected all over Somalia (SRCS, 2021).
Currently, the almost complete failures of five successive rainfall seasons, rising food prices and severe water shortages are adding up to another stressful situation putting over 800.000 people in need of emergency assistance (National Drought Committee, 2022). This number is projected to rise substantially if the current drought conditions persist (Swanson et al., 2022).

Shallow wells and most Berkeds have dried up, leaving boreholes and expensive water trucking as the last options for water supply (National Drought Committee, 2022).
Cascading droughts can have cascading impacts as affected people are forced into bad feedback-loops to respond to the immediate crisis, reducing their coping capacity and thus further increasing their vulnerability to future events (USAID, 2018). USAID (2018) hypothesised, that these post-shock impacts can better be mitigated by early interventions than by late response. Although, (USAID, 2018) states, that there is very little data to support this statement and that it is primarily based upon logical deduction and not field data. Nonetheless, this assumption is also supported by Ali and Jemal (2017), Abdulkadir (2017) as well as by the growing community of Forecast based Financing practitioners (Gualazzini, 2021; Harrowsmith et al., 2020).

2.5.5 Risk Prevention Measures

The 2011 famine in Somalia was projected 11 month in advance. Despite this early warning, the international community failed to react adequately and in time to prevent the worst (Hillbruner & Moloney, 2012; Stephens et al., 2015). Subsequent evaluations point to two main areas of concern. On the one hand, there was a lack of timely funding, and on the other hand, the concept of preventive action had not yet permeated the humanitarian community and response activities were still seen as the standard (Stephens et al., 2015). This failure, as well as the successive improvements in forecasting and the growing scientific interest and knowledge about the positive impact of early warning and anticipation measures, laid the foundation for the current development of the EAP for Somalia. As the project is still in progress, detailed information is not yet possible to present in all areas and the presented information is also subject to constant changes and future developments. Nevertheless, critical points for this work can be derived and the need for further developments can be elaborated.

The interest to develop an EAP for a slow-onset hazard such as drought only recently started to become more popular within the RCRC as the focus laid on fast-onset disasters thus far (RCRC, 2020). RCRC (2020) presented the first adaptation of the general manual of the IFRC (see IFRC et al. (2023a)), merging experiences of pilot projects to adjust guidelines for the development of FbF and Anticipatory Actions in the context of drought. Currently, at least seven National Societies (Kenya, Uganda, Ethiopia, Zimbabwe, Somalia, Lesotho and Niger) are planning, developing or have recently completed a drought EAP (Lesotho Red Cross Society & IFRC, 2022; RCRC, 2020; Society & IFRC, 2021).

The Somalia Red Crescent Society (SRCS) has completed their preliminary *Feasibility Study on Potential Use of Forecast-based Financing (FbF)* in June 2022. A pilot study shall be conducted to test practical implementation feasibility in Somaliland and potentially Puntland with emphasis on, from highest to lowest priority: droughts, health, (flash) floods, cyclones, locusts, and conflicts. Besides the detailed description and justification for each type of disaster, the assessment also confirmed the good postition of the SRCS to undertake such a FbF program and to embed it into the general Disaster Risk Management.
The implementation of a FbF program cannot be done by a National Society alone. Besides

the SRCS numerous other stakeholders will take part in providing information, resources or knowledge as well as acting upon aforementioned. The landscape of actors is wide and includes many local, regional, national and international governmental and non-governmental groups, initiatives, centers and organisations. To name but a few: The Ministries of Agriculture (MoA), of Water Resources (MoWR), of Health Development (MoHD) and of Humanitarian Affairs and Disaster Management (HADMA) and others include Somaliland's state actors. Building Resilient Communities in Somalia Consortium (BRCiS) and Somaliland Community Disaster Risk Management Committees (CDRMC) compromise local and regional NGO networks and committees. The UN (FAO, OCHA, and UNDRR), WFP, WHO, World Bank, WMO, GRC, NRC and IFRC are a selection of international actors engaged in Somalia. Added to this are a number of other think tanks, climate centres and forecasting providers, making the integration of the respective actors an important but also intricate affair, especially in the light of the multi-faceted nature of droughts (RCRC, 2020; SCRS, 2022).

Forecasts are also provided by various organisations and scales. The FEWSNET releases famine warnings and reports for the entire african continent on a regular basis (FEWSNET & USAID, 2023). Regional forecasts are provided by the Climate Predictions and Applications Centre (ICPAC) based on global models for the Greater Horn of Africa region (ICPAC & WMO, 2023). More small-scale prognoses are released from FAO's SWALIM and FSNAU programs which monitor different drought indicators based on relatively few weather stations (100 manual and 10 automatic in all of Somalia) and remotely gathered and modelled climate information (FAOSWALIM, 2014; SCRS, 2022). There are two other local seasonal forecasts issued by government agencies and disseminated by the responsible agency, NADFOR, to stakeholders at all levels for natural hazard warnings (SCRS, 2022). Besides SRCS's own disease CBS informing actions for health related issues, data of local circumstances influence forecasts only scarcely and infrequently.
Up to this point, it has not yet been decided which prediction and reaction trigger should be chosen for the SRCSs' EAP but it will inevitably be based on scarce coverage and primarily large scale data, as it is the case for the EAPs in Niger and Lesotho (Lesotho Red Cross Society & IFRC, 2022; Society & IFRC, 2021).

The trigger methodology will be a staggered trigger, following current recommendations of the RCRC (2020) but its definition remains a challenge due to the currently very tense situation and the medium-term changes in weather and climate over the last 10 years. Under these conditions, it is quite difficult to determine a *normal* period against which *drought events* can be measured and will ultimately depend on the chosen forecast. Conceivable triggers could be the predicted failure of one or more consecutive rainy seasons or a specific classification warning for food or water insecurity and will further depend on selected actions. Gettliffe (2021) found, that triggers need to be linked to their respective intervention, or otherwise will "led to significant challenges" (p.19).
Identified actions by the feasibility study of the EAP for drought interventions are water storage rehabilitation, de-stocking, early or alternative short growth crop planting, cash distributions,

women and children shelters as well as water trucking (SCRS, 2022). The Ministry of Livestock and Fisheries Development notes, that de-stocking will hardly be feasible due to little trust in forecasts by livestock owners as well as the absence of a internationally approved abattoir which limits the amount saleable meat to local market capacities (SCRS, 2022). Gualazzini (2021) propose water vouchers as viable alternative to water trucking in regions where a functional market of private water vendors already exists. Besides AAs, adequate policies for water management, price regulations, and allocation mechanisms are seen as potential opportunities to mitigate further drought impacts (Gualazzini, 2021; W. Wang et al., 2016).
Along the mentioned forecasts of natural phenomena, SRCS has successfully set up a CBS project to monitor and react to disease outbreaks on community level since 2018, see section 2.4.3 and Jung et al. (2022).

Alongside SRCS and IFRC, OCHA and BRCiS also developed anticipatory action plans for Somalia in recent years. OCHA followed conventional frameworks in regard to forecasts and triggers with their pilot study in 2020, using large scale indices with a combined trigger of pre-identified thresholds (Gettliffe, 2021; OCHA, 2020). Chosen actions comprise all major fields of food security, WASH, education, health and risk communication, often with lead times of multiple weeks to months. In their evaluation, Gettliffe (2021) synthesized many lessons learned in all areas, highlighting the buy-in of all stakeholders, early expectation setting, the importance for parallel development of AAs together with explicit, linked and robust trigger mechanisms. Cash transfers were "identified across several clusters as the preferred action" (OCHA, 2020, p. 21) where local markets and the operational context allow it (Gettliffe, 2021).

BRCiS created their own Community Real-Time Risk Monitoring Systems (CRTRMS) to integrate local information. The CRTRMS is based on key informant interviews from a selection of a small group of 2-3 communities which represent a larger population of 10-12 communities. These information are then triangulated with regional, national and international secondary information sources to ultimately propose relevant anticipatory measures. The survey together with the triangulation should allow triggering within 12 days after data collection but commonly averages on 25 days in practice. Besides the relatively long duration, key informants are well aware, that their given information may influence the amount of humanitarian assistance in the area, highlighting the importance of trustbuilding and data triangulation (Gualazzini, 2021).
Indicators and thresholds are categorized into *normal*, *alert*, and *alarm* allowing for *red-flagging* of areas based on either one very strong impact or on a pre-defined amount of cumulative impacts in multiple areas. For example, one indicator is the condition of primary water sources in communities and is assessed at the end of the rainy season and categorized based on their water level into normal *(more than half-full [75%] or full)*, alert *(half-full [50%])* or alert *(less than half-full [25%] or empty)* allowing for a seasonal prediction and corresponding flagging.

2.6 Literature Summary

This chapter outlined the overall theoretical background of the case studies context by starting with the concepts of Water Security, Drought, and Water Scarcity. These are wide ranging concepts, complex in nature and various definitions exist for each of these. Water Security links an extensive network of interrelated trans- and inter-sectoral systems together and can be seen as umbrella term for the extensive web around water availability and its many components. Water Scarcity, as it is understood in this work, has a physical and economic aspect which refer to the availability of water resources and the various economic conditions for its extraction, respectively. Therefore, the absolute lack of water in the current situation, water shortage, always has a human (long-term) dimension, particularly on the demand side. Drought is most often considered in four stages, namely meteorological, agricultural, hydrogeological and socio-economic drought with each having their specific sets of impacts, indicators and indices. Drought, as natural hazard, is differentiated to aridity by its short but severe nature. Conceptual definitions give an idea and set boundaries to the concept of drought while operational definitions focus on its onset, duration, severity and spatial coverage.

Measuring and predicting droughts is complex and often multiple individual or sets of indicators and indices are combined to get a full picture of the situation. Indices are themselves often composites of multiple indicators and mathematical functions. The intricate and interconnected nature of droughts leads to uncertainties in forecasts, making it more difficult to define impact thresholds for anticipatory measures. Impact is generally expressed by a combination of hazard severity, the exposure of assets and their vulnerability. The latter three often summarized in the term risk.

Forecast based Financing (FbF) is a relatively newly emerged phenomena in the realm of humanitarian aid that promotes Anticipatory Actions before the impact. The FbF approach is based on impact forecasts which predict what the weather will **do**, instead of conventional forecasts that predict what the weather will **be**. This is preceded by a hazard and risk pre-assessment to identify thresholds on which to trigger pre-defined actions that ultimately help to reduce the impact, documented and defined in an Early Action Protocol. For successful implementation, triggers and actions should be developed together and directly coupled. In the context of water sources in Somaliland, this is generally not feasible as local information data is either outdated or missing completely.

Citizen Science (CS) is the involvement of citizens in scientific or public endeavours and can promote various benefits to all engaged stakeholders if implemented and operated correctly. Citizen Science, similar to the above concepts, is wide-ranging and complex. Under this umbrella, Community-based Surveillance (CBS) together with Mobile Crowdsensing provide practically realizable frameworks and guidelines for the successful application of CS specifically in regard to remote data collection. CBS and Community-based Water Monitoring (CBWM) demonstrate the feasibility in the local context and transferability of these concepts, respectively.

Somaliland lies within the Great Horn of Africa and can geographically and climatologically be seen as a generally arid and water scarce region with poor soils, scarce vegetation and limited water resources. It has historically been troubled by droughts, as well as internal and external conflicts, which regularly exacerbate the already tense situation. Somaliland is one of the poorest regions in the world but managed to develop a relatively stable democracy for the last 30 years. Currently, many local, national and international organization work on mitigating and responding to a further tense situation with famine expected in mid-2023.

Certain limitations and gaps could be identified in the above conducted literature review. The concepts of Water Security, Water Scarcity and Drought need to be clearly defined and broken down to the specific region and application. Unfortunately, the long history of conflicts and insecurities severely limited scientific research in Somaliland in particular, which generally led to little scholarly information on the region.
While numerous international forecasts exist and local assessments start to emerge, timely, highly local and up-to-date data is not available for many areas of interest. Thus, the direct link of trigger and Anticipatory Actions (AAs) is often not given, making the implementation less effective, efficient, targeted and time consuming.
The concept of FbF is generally well established by now, but the drought use case is new and not yet well researched, which greatly limits the amount of guidelines and frameworks available for this particular application. Thus, each new project and study has, at least in part, an exploratory character.
Citizen Science projects in regard to water are geographically primarily focused on North American and European countries, relating most of the scientific findings to the respective context. Furthermore, these water related projects mainly focus on river, lake or groundwater level or water quality monitoring and not on direct community water source investigations to facilitate AAs. The review of data availability and reliability of current datasets revealed a clear need for more up-to-date and complete information on water source locations and characteristics, especially with regard to the highly important water type of berkads.

Chapter 3

Methodology

The chapter begins with the overall research design. Presents a brief overview of the methods used for the literature analysis and is followed by a description of the research type *case study*, its justification and specifications. The methodology for selecting and conducting the interviews is described subsequently. The design frameworks on which the upcoming development is based are then presented in their original form. This includes the Six-Stage-Framework (SSF), which provided the overall process-oriented stage structure and the rough content orientation of the Six-Stage-Design-Roadmap (SSDR), and the Seven-layer model of collaboration (SLMC), which guided the development of the Project-Requirements-Catalogue (PRC). In order to adequately answer the two research questions building on these two main frameworks, they are complemented by a number of other guidelines and recommendations, which are briefly presented in the penultimate section of this chapter. A summary of the most important methodological and conceptual elements concludes this chapter.

3.1 Research Design

This work primarily applied an inductive perspective on quantitative analyses of conducted programs, projects and literature to synthesise best practices and guidelines. It also applied interpretive methods like interviews to gain new expert knowledge about the context and realities of the case study to build and apply new theory. Therefore, a combination of approaches will be reflected in a mixed-method approach which benefits of both, quantitative and qualitative data.

The **background analysis** started with the review of the already established document database of the overarching EAP development and was subsequently extended. Broad concepts were used as a basis to lay a thematically large, yet steadily more specific foundation. For the in-depth analysis of previous CS projects and further insights into the case study itself, grey and peer-reviewed literature was consulted. Grey literature, as academic literature specifically on Somalia was found to be generally scarce. The search was based on different combinations of keywords and their synonyms which could be derived from the underlying concepts and their respective specifications. Furthermore, in the course of the work, more specific literature and

project suggestions were received from the project team and the interviewees. For the selection of CS projects, core areas of interest were formulated and derived from the thematic focus of the fundamental concepts and research aim. Therefore, the thematic focus was either on community-based participatory environmental or risk monitoring with regard to the issue of water, or on local projects using comparable methods. In the first case, geographical location, size or technical facilities were no exclusion criteria. Subsequently, the projects were tabulated and jointly evaluated manually, since the absolute number of projects finally selected was manageable without additional software.
Available data about water sources in Somaliland was analysed via QGIS3. In total, five data sets about water sources in Somalia, a settlement layer and administrative boundaries were downloaded from the spatial FAOSWALIM database, see Appendix A. Three of the five water source data sets were different time instants of a single data series. All layers were projected to WGS84 / UTM zone 38N and subsequently clipped to the boundaries of Somaliland. The following analysis of the data was primarily exploratory, and extended with a basic statistical analysis.
In addition to the thematic focus on water-related issues, the methodically comparable practical implementation on the ground was investigated by analysing the already established CBS program of the SRCS. This was done primarily by interviewing the responsible managers.

The **research type** that "allows in-depth, multi-faceted explorations of complex issues in their real-life settings" (Crowe et al., 2011, p. 1) is the *case research* or often just called *case study*. This definition goes back to Yin (1984) and highlights the core strengths of this approach. The research type of the case study is particularly well suited for exploratory, rather than for descriptive or explanatory research, closely examining circumstances within a specific geographical area and context (Zainal, 2007). Here, various quantitative and qualitative forms from both historical and real time data can be investigated and examined directly in its given context (Fitzgerald, 1999). This allows for a detailed, multi-perspective and specific investigation of that particular topic of interest, which might not be given when examining the parts individually (Pelz, n.d.; Zainal, 2007). Yet, case studies also comes with a number of trade-offs.
More extreme critics see the case study method only as a loose 'story', which in the worse case is even connected to the scientist himself (Fitzgerald, 1999). This criticism refers to the lack of rigour and "very little basis for scientific generalisation" (Zainal, 2007, p. 5) which can lead to low external validity (Yin, 1984). The internal validity often remains weak due to no or poor experimental control complicating causal relationship testing and the multifaceted nature of case studies make it dependent on the researcher and prone to bias and some kind of subjectivity. Besides the internal and external validity, constructed validity and reliability need to be accounted for. Constructed validity refers to "the extent to which a study investigates what it claims to investigate" (Gibbert et al., 2008, p. 3) so that "the researcher can correctly evaluate the studied concepts" (Ferreira et al., 2020, p. 277). It can be addressed by establishing a clear chain of evidence and triangulation of perspectives and sources (Gibbert et al., 2008). Repeatability by other scientists using the same methodology to arrive at the same insights is termed 'reliability'. Repeatability refers therefore to the "absence of random error" (Gibbert et al., 2008, p. 5)

and can be enhanced by clear procedures and good documentation. Furthermore, case studies are frequently criticized for being excessively long, challenging to execute, and requiring significant documentation efforts (Yin, 1984). Since all research types have their advantages and disadvantages, it is primarily a weighing of these strengths and weaknesses that determines the choice of research type. The strength of the *case study* make this research type ideal for addressing the aim of this study, as it allows for a holistic exploration and understanding of novel and under-researched areas within a "complex and dynamic context where it is difficult to isolate variables or where there are multiple, influencing variables" (Fitzgerald, 1999, p. 2). Therefore, a case study is an excellent method not only to test theories but also to develop new theories and frameworks, as it is the aim of this study (Pelz, n.d.; Zainal, 2007). Comparable studies, such as Asiimwe et al. (2011), Frigerio et al. (2018), Kohlitz et al. (2020), and Minkman (2015) and Weeser et al. (2018) have also successfully applied this research type.
Along with the exploratory strategy, an iterative strategy was adopted, referring to the "visiting and revisiting [of] the data and connecting them with emerging insights, progressively leading to refined focus and understandings" (P. Srivastava & Hopwood, 2009, p. 77). Thereby, each interview or questionnaire was directly transcribed, coded, analysed and merged with previous insights. Along with the conducted literature analysis, newly acquired knowledge could thus be evaluated, triangulated, integrated and subsequently be used as a basis for further research and interviews allowing for deepening and refining of knowledge piece by piece.

The selection of **interviewees** was based on a strategy of targeted expert sampling, i.e. a non-probability method that focused on reaching key informants and conducting expert interviews. This technique was employed as the expertise and experience of the individuals was crucial rather than focusing on broad, generalisable statements (Pelz, n.d.). This method was further extended by adopting a snowball sampling approach which helped to identify further stakeholders and potential candidates.
The target persons were primarily people who know the local context and are potential stakeholders in a possible implementation of the design in question. The first interview came about through existing contacts of the overarching EAP development project in which this work is embedded, and the interviewee was the project leader of the FbF approach in the SRCS (I1). In the further course, the CBS project manager of the Norwegian Red Cross (I2) and the CBS manager on the Somali side (I3) were also interviewed. Between these two interviews, there was a second interview with the project manager of the SRCS' FbF team (I1.2). More interviews with representatives of the Ministry of Water Resources, NADFOR, FAOSWALIM, BRCiS and the technicians responsible for the NYSS platform were envisaged but could not be conducted. The interviews with the project leader on the SRCS side unfortunately had to be replaced by written questionnaires, as circumstances did not permit a personal interview. For the conversion of the interview guidelines into questionnaires, the recommendations of Harkness et al. (2016) were followed. The interviews and questionnaires themselves were semi-structured and mostly consisted of open ended questions to allow for the interviewee to give a free response as opposed to predefined answer options, see Appendix B. Open-ended questions can facilitate more detailed answers, new insights and overall allow for an unlimited response in terms

of scope and focus while they also complicate relevant information abstraction and following analysis (Pelz, n.d.).
The intelligent verbatim transcription of the interviews was facilitated by the newly developed neural net called Whisper (OpenAI, 2022, 2023) and subsequently manually checked and corrected in MaxQDA 2022. For the further analysis, the recommendations of Rädiker (2020) were followed. The coding strategy followed an inductive, open thematic manual coding approach. Codes were not strictly predefined, to be able to appropriately incorporate newly gained expertise, but only broadly categorized into the main themes of interest. More dedicated coding approaches based on e.g. the grounded theory or the hermeneutic analysis were not applied, as the given information was the focus of interest and not e.g. the identification of subjective constructs and underlying meaning (Pelz, n.d.). Nonetheless, based on the criticism on positivism, provided information was not taken as unbiased and objective but interpreted in the context of its perspective.

3.2 Design Frameworks

The design of the roadmap for community-based water source monitoring was particularly guided by the framework of Fraisl et al. (2022). This framework was chosen as it is very up-to-date, incorporates many guidelines and best practices, and structures them in an efficient and process-oriented way, with a focus on practical applicability. It covers the entire life cycle of a Citizen Science project in its six phases in an iterative way, starting with problem assessment and finishing with evaluation procedures. However, the focus is on ecological and environmental projects, which necessitated a thorough revision of the content.
The framework was tailored to the study area and research aim by adapting and extending it with other thematic and context related experiences and guidances. Stage 1 was extended by context specific topics and Stage 2 majorly expanded with a feasibility assessment based on the IFRC (2017). The biggest expansion, however, came from the third stage onwards. From here on, the SSF was additionally accompanied by a self developed Project-Requirements-Catalogue (PRC). The PRC was primarily structured along the Seven-layer model of collaboration design pattern and incorporates the recommendations of several other guidelines as well as gained knowledge through the literature review and the project analysis. This fundamentally expanded the process-oriented SSF structure with a requirement and dependency focussed skeleton in order to further reduce cognitive overload, see section 4.2.
The original version of the utilized frameworks, the SSF and the SLMC, followed by a section about several other CS guidelines will be presented in this section. This lays the foundation for the results related to the first research question in sections 4.1 and 4.2 and enables further application in section 4.3 to address the second research question.

3.2.1 Six-Stage-Framework

In their work, Fraisl et al. (2022) pull information from all kinds of CS programmes, projects and scientific guidance. Although thematically focused on projects in the field of ecology and environmental sciences, the underlying principles described here are also applied in a variety of thematically differently oriented projects (Fraisl et al., 2022). The developed Six-Stage-Framework (SSF) concentrates on the participation level (1) crowdsourcing and (2) distributed intelligence. On these levels, citizens are primarily contributors and partly asked to interpret the sensed information. This was outlined in chapter 2.4. All six stages are interconnected and should all be considered throughout the project to incorporate new information, feedback and lessons learned (Fraisl et al., 2022). An overview of the *citizen science project life cycle* can be seen in figure 3.1.

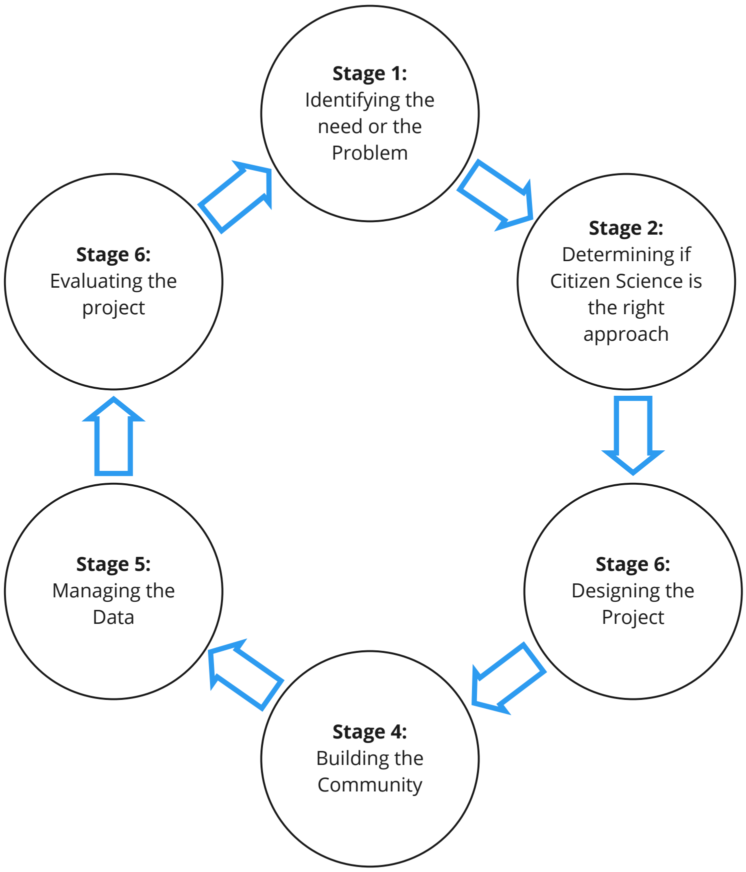

FIGURE 3.1: The Six Stages Framework for designing a citizen science project in ecology and environmental sciences. Source: Own representation based on Fraisl et al. (2022, p. 4)

In stage 1 the overall need and problems are identified and their boundaries defined. This includes the gathering of potential solutions, limitations and the formulation of research questions. Stage 2 closely examines the potential application of CS in the identified boundaries. The focus is on the fruitfulness of the involvement of participants to reach the formulated objectives and answer the research questions. This may be related to many project specifications, e.g. temporal and spatial scale, required expertise and intended target groups. As the second major consideration for the reasonable integration of CS participants, Fraisl et al. (2022) note, that the project need to benefit the participants by "addressing their needs or fostering new skill and expertise" (p.2). After problems, needs and applicability are addressed, the objectives and aims of the project need to be defined in detail together with the prospective stakeholders in stage 3. In addition to the main objectives, secondary objectives such as awareness and knowledge building as well as its transfer could also be pursued. Establishing an initial foundation for concerns of privacy and ethics, data storage and analysis, selection of methods and training strategies as well as means of communication and respective instruments is also part of this stage. Furthermore, the tasks of the participants need to be defined in detail, also including any benefits and safety considerations. Stage 4 is concerned with the building of the community by identifying participants motivations, education levels and other demographic information as well as issues of acknowledgments, feedback and sustaining participation. Planning of data management in terms of collection, storage, Quality Control (QC) and Quality Assurance (QA), analysis and privacy and security are highlighted in stage 5. Although evaluation is the main theme of stage 6, it is seen more as an ongoing effort that is recommended throughout the project to allow for feedback and improvement at each stage.

3.2.2 Seven-Layer Model of Collaboration

The design pattern of the SLMC was utilized to develop a new requirement focussed catalogue to enhance the applicability of the SSF from stage three *designing the project* and onward to better handle and structure the high complexity and interdependences. The SLMC was specifically designed to reduce cognitive (over-)load for the design of a complex, interrelated project in a social-technical context. It does so, by separating concerns at design time into seven layers and corresponding methods and techniques. These, as presented by Briggs et al. (2009), are primarily aimed at the collaboration of groups, but the overall pattern can be preserved when applied to designs in other contexts (Diggelen & Overdijk, 2009). Therefore, the following explanations of the individual layers, their methods and techniques are adapted to this work, while maintaining the general pattern, see Briggs et al. (2009). The seven, slightly adjusted layers are: Goals, Products, Activities, Methods, Techniques, Tools and Scripts, see figure 3.2.

The layers are ordered hierarchically with Goals being the top-most layer. Changes made in one layer, may need to be accounted for in the lower, but not necessarily in the upper layers. The *Goal-Layer* incorporates all overarching goals and objectives of the project. The *Products-Layer* sums up all tangible or intangible components or outcomes that are necessary to achieve the formulated targets in the *Goal-Layer*. The required activities that yield these products, are grouped in the *Activities-Layer*. These activities formulate what needs to be done in order to create the necessary products and can have sub-products and sub-activities of their own. The fourth *Method-Layer* is the most different from the original, as it does not deal with the procedures of collaboration but with the methods used in the activities. The *Techniques-Layer* specifies the involved techniques and practices and the *Tools-Layer* summarises all relevant artifacts or apparatus used. The final procedures are described in detail and defined in the bottommost layer, the *Script-Layer*. Further concerns, interactions and justifications between and for each layer are extensively described by Briggs et al. (2009) and while there is a lot of value in these remarks, the thematic adaptations and focus of this work make further exploration in this context obsolete. Nonetheless, interested readers are invited for further independent exploration. In this work, emphasis is given to the top three layers, the *Goal-, Products-, and Activities-Layer* as these could be handled in terms of the level of detail without having to be on site.

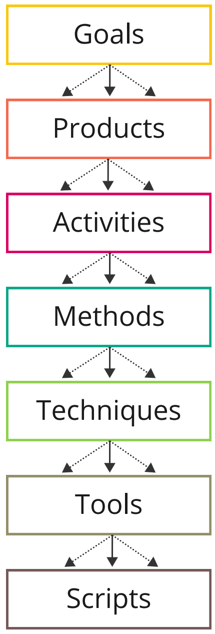

FIGURE 3.2: The Seven Layer Model of Collaboration. Source: Own representation based on Briggs et al. (2009)

3.2.3 Citizen Guidelines & Recommendations

This section presents some further guidelines and recommendations that have been used to complement and adapt the framework described above to the objective and context of this work. These recommendations, frameworks and guidelines for Citizen Science projects have become numerous and thematically wide-ranging. Networks and programmes of researchers and practitioners covering all or parts of the stages proposed by the SSF are spatially widespread at the global level and include a variety of regional, national or global application levels. Some examples of such networks and programmes are government programmes such as the US-run citizenscience.gov website or the EU platform eu-citizen.science, support platforms such as CitSci and the Citizen Science Center Zurich as well as regionally focused associations like La Red Iberoamericana de Ciencia Participativa (RICAP), CitizenScience.Asia and the Citizen Science Africa Association.

Besides these knowledge-hubs, a vast variety of different scientific and and grey literature exists. Fraisl et al. (2022) and Weston and Conrad (2015) have each listed and summarized many recommendations and García et al. (2021) even created a guide to citizen science guidelines.

Furthermore, Minkman (2015) derived a set of six potential goals which could be addressed

through Citizen Science in water management namely (a) awareness raising, (b) public education, (c) policy development, (d) method improvements, (e) knowledge building, and (f) management improvements. The demarcation between the individual goals can be fluid and is not rigidly predetermined. Each CS project can address multiple of these goals and with varying emphasis. These goals were derived in cooperation with water management authorities in the Netherlands and concentrate on objectives that can be implemented in practice.
Although the overall objective of this work was already defined, all these six goals by Minkman (2015)were chosen as a starting point for further exploratory analysis in order not to overlook potentially useful secondary goals. These six goals formed the first layer of the SLMC in the development of the PRC. Further emphasis was given to the findings of the BRCiS network and IFRC's CBS and FbF guidelines, manuals and recommendations. Further information of the above-mentioned projects, programmes, associations and others was integrated by extracting the key findings and guidance from the respective papers and projects, categorising them along the stages and then integrating them into the stages of the newly developed framework.

3.3 Method Summary

This chapter presented the research design and methods used, as well as the framework conditions that guided the design and application of the study. This work was embedded in a primarily inductive research design of an exploratory, iterative case study, and adopted a mixed-method approach with data and document analysis as well as expert interviews. The development of the new community-based water source monitoring framework was primarily based on two frameworks, the Six-Stage-Framework (SSF) and the Seven-layer model of collaboration (SLMC). The SSF primarily provided the structural basis and content orientation for the development of the process-oriented Six-Stage-Design-Roadmap and the SLMC gave orientation to the creation of the Project-Requirements-Catalogue. Moreover, several other guidelines and recommendations were outlined which were incorporated to complement and adapt the two main frameworks to this research's aim and context. The expert interviews conducted subsequently enabled the application of this new and adapted framework to create the implementation roadmap for Somaliland.

Chapter 4

Design and Application

The design of the Six-Stage-Design-Roadmap (SSDR) along with the Project-Requirements-Catalogue (PRC) and its subsequent application for implementing the research aim is presented in detail in this chapter. As usual in the research design *case study*, the results partly build on each other and evaluations had to be made in the intermediate steps to allow further continuation. This results-centred chapter will therefore also have small parts of further explanations and discussions of interim results, to allow the flow of thought to follow the decisions made. Nonetheless, these parts were kept to the bare minimum, leaving major discussions to the next chapter.

In the opening section, the newly developed 4.1 for community-based participatory mapping and monitoring of water sources for water-scarce and resource-limited settings to facilitate relevant AAs in the context of FbF addresses the first research question. The developed Six-Stage-Design-Roadmap is a highly adapted and extended version of the SSF taking into account the setting of the case study area, the research context and several other guidelines. The Six-Stage-Design-Roadmap is further accompanied by the also newly developed PRC, which is presented in section 4.2 of this Chapter. The interplay between the SSDR and the PRC can be seen in figure 4.1. Section 4.3 addresses the second research question by presenting the created implementation roadmap for a practical project in Somaliland, which resulted from the application of the new SSDR together with the PRC on the Somaliland context.

The data used are listed in Appendix A and the full interview and questionnaire transcripts can be found in Appendix B. The chapter concludes with a short summary containing the main findings.

4.1 Six Stage Design Roadmap

The six stages of the SSDR are presented in the coming sections. The design of the roadmap is primarily oriented on the SSF but additionally incorporates several other CS project guidelines and experiences, information from the conducted interviews, and the wider literature. While the stages conceptually separate the design process, it is important to keep in mind, that the stages are interconnected and in particular stages 3 to 6 can and should be worked on to some extent in parallel or iteratively. Stages 1 and 2 are primarily important in the beginning and when major changes of goals or conditions take place during the design, implementation or operation phase. Thus, once the first two stages are successfully conducted, the actual design procedure will be an iterative process, that mainly incorporates these last 3 to 6 stages. This, and its interplay with the PRC can be seen in figure 4.1.

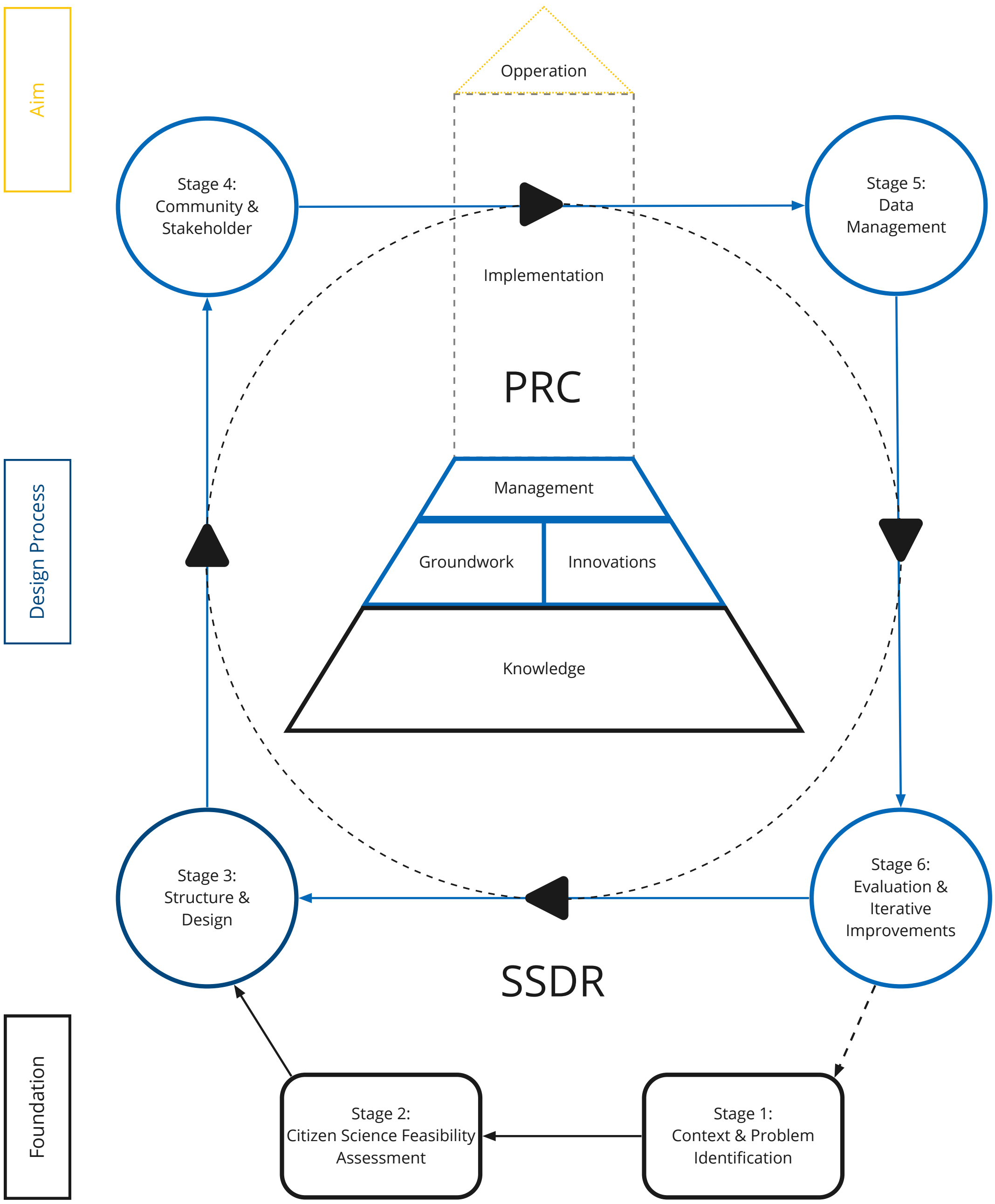

FIGURE 4.1: Interplay of SSDR and PRC. Stages 1 and 2 of the SSDR form the basis for the subsequent work in stages 3 to 6. The PRC enables the design to be built up in a structured way, ultimately leading to operation via an implementation phase. Source: Own representation.

Stage 1 outlines the exploration phase to establish a first understanding of the problem, context and potential solutions. The second stage elaborates on how to conduct a feasibility study to evaluate the CS approach regarding the identified problem in the given context. When the feasibility of the CS approach is confirmed, the overall structure of the project is laid out in Stage 3 *Designing the Project*. This stage describes the usage of the gathered information of stage 1 and 2 to further specify the research goal, respective products to reach these goals and the activities that constitute to the products. More guidance is given to which additional data needs to be collected, assessed and integrated to lay a good foundation for the coming stages. Stage 4 is concerned about topics surrounding community building efforts and Stage 5 outlines concerns in regard to data management. The last Stage, *Stage 6 Evaluation and Iterative Improvements* underlines the importance and elaborates on the practical implementation of ongoing assessment and improvement measures.

4.1.1 Stage 1: Context & Problem Identification

This first Stage is the exploration phase of the overall project (CitizenScience.gov, n.d.). This is where the environment of this project is established, in which itself is embedded. It is aimed at identifying prevailing conditions in all areas that may be covered or touched by the project. Even if this stage does not go into too much detail, the identification efforts must be thorough and as complete as possible. Oversights in this stage can have serious consequences in later stages. To enable this identification, project boundaries must first be defined by the overall objective and the problems to be solved, which also take into account challenges, positive and negative constraints as well as resource requirements. In addition, potential key stakeholders should be involved from the beginning and comparable projects and data sets need to be carefully identified and analysed to avoid duplication (CitizenScience.gov, n.d.; Fraisl et al., 2022; Minkman, 2015). Based on this information, possible solutions can be derived and hypotheses or research questions formulated (Silvertown, 2009). Additionally, evaluation practices and sustainability considerations should be integrated into the project as early as possible although they are only defined in detail at a later stage (Fraisl et al., 2022).

4.1.2 Stage 2: Feasibility Assessment

The Citizen Science approach is not feasible for all kinds of projects. Certain criteria should be met and the feasibility of design, implementation and operation must be ensured and tailored to the decision-making processes that the project aims to influence. Fundamentally, a CS project must contribute to achieving the defined objectives and solving the problems, while also providing benefits to the participants, e.g. in terms of knowledge, community or recreational value (ESCA, 2015). The feasibility assessment needs to consider various factors and constraints in more detail than in Stage 1 to identify information and management gaps accordingly. The clear definition of the relevant CS sub-concepts and levels of participation is crucial for the feasibility assessment. It is also important to clearly outline the boundaries and concepts by which and within which the project is to be confined and embedded. The goal should be clarified along with potential sub-goals and related products which need to match the derived gaps and the capacity of the implementing organisation (IFRC, 2017; Minkman, 2015). The organisational capacity depends on financial, human and technical resources, knowledge and experiences, embedding in decision-making networks and structures, and the organisational commitment and dedication of those involved (Fraisl et al., 2022; IFRC, 2017). The importance of securing (long-term) funding is also highlighted by many guidelines (Cervoni et al., 2008; Minkman, 2015; Sharpe & Conrad, 2006; Whitelaw et al., 2003). Existing data sets and potential tools need to be analysed and assessed for suitability. In addition to the positive constraints, the IFRC (2017) has defined negative *red flag* constraints which, when they occur, should stop further design developments until they can be resolved appropriately. Going back to the exploratory Stage 1 to explore and evaluate the issue may be necessary if a *red flag* should be reached. The adapted *red flags* are:

- A need does not exist.
- The community does not want the project.
- Barriers and fears of: information usage, data sharing, applied technology and different cultural beliefs.
- Insufficient capacities regarding financial and human resources, knowledge, experience and phone coverage.
- No support of key stakeholders.
- No or insufficient response possibilities.

Based on IFRC (2017)

4.1.3 Stage 3: Structure & Design

This stage builds on the identified context and conditions of stage 1 and the feasibility study of stage 2 and creates the broader framework for more specific work in Stages 4, 5, and 6. The goals and research questions are considered again and finally specified and formulated in alignment with the projects, participants and stakeholders interests and aims (C. C. Conrad & Hilchey, 2011; Minkman, 2015). Previous assumptions should be backed up as much as possible and made explicit (Silvertown, 2009) and biases need to be addressed (ESCA, 2015; Fraisl et al., 2022). "Legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities" (principle 10, ESCA (2015)) need to be considered. The design need to be thoroughly embedded in the context and anchored by policies, preferably in an Integrated Water Resource Management initiative (Cervoni et al., 2008; Sharpe & Conrad, 2006) and ongoing FbF implementations and efforts. The 'light' IWRM *community-based water resource management* framework by (Day, 2009) is recommended as a starting point as it is geared towards practical feasibility, see section 4.2.2. The integration into the FbF is done by targeting data management (stage 5) on indicators which support intended triggers and respective anticipatory actions (IFRC, 2017). Adequate and scientifically justified thresholds and monitoring methods may need to be developed and triangulation data sets identified, assessed and integrated.

A structured and interconnected foundation needs to be created for the integration of communities and stakeholders (Stage 4), data management (stage 5) and evaluation and iterative improvement procedures (stage 6). Community building encompasses recruitment, training, task specifications and participant benefits, motivations, feedback mechanisms and stakeholder acknowledgements. It is also concerned with the broader frame of partaking and collaborating non-governmental organisations and government bodies at all levels (C. C. Conrad & Hilchey, 2011). Data management practices should be oriented on already proven concepts of comparable projects, identify and define data collection, transmission, storage and analysis aims, formats, and types (Fraisl et al., 2022; Gualazzini, 2021; IFRC, 2017). Consideration also needs to be given to the ways in which the new data from this project can be publicly displayed, accessed and used to improve completeness, timeliness and overall quality of information and decision-making processes (C. Conrad, 2006). Evaluation and iterative improvement procedures are concerned with pre-defining success metrics which should be considered during the entire project design and operation.
In this third stage, the project requirements catalogue presented in the coming section 4.2 is recommended for integration to reduce mental load in the further design process.

4.1.4 Stage 4: Community & Stakeholder

This section pertains to the identification and establishment of all relevant factors associated with the participants, community, network, and organizational and governmental stakeholders and decision-makers. Understanding participants characteristics and motivations as primary data collectors and contributors to the project is of great importance for the sustainable success of the project. Their characteristics can include, among others, the educational level, skills and demographics (Cervoni et al., 2008; Fraisl et al., 2022). The motivational aspects comprise elements of interest, engagement, acknowledgements and overall gained benefits. The first set of characteristics can be addressed by training, supervision and provision of feedback, especially for new participants (ESCA, 2015; Fraisl et al., 2022; Minkman, 2015; Sharpe & Conrad, 2006). Providing feedback to the actual contributions but also in terms of how the contributions influence planning and management decision-making processes and outcomes can positively influence the motivational aspects (C. Conrad, 2006; C. C. Conrad & Hilchey, 2011; Whitelaw et al., 2003). Creating wider public engagement and interest can further enhance motivational factors such as recognition and community building (C. Conrad, 2006). Community events and networking bring further social benefits, trust and belonging and open up opportunities to engage directly with decision-makers and make them aware of what this project is and why it exists (C. Conrad, 2006; Fraisl et al., 2022; Sharpe & Conrad, 2006). Decision-makers, such as respective water and risk related government ministries and agencies, should be integrated in the process and design right from the beginning as especially local and regional leaders can help to implement and operate the project on site (Gualazzini, 2021; IFRC, 2017). They can furthermore help to sensitize the community, manage expectations and inform about and support in dealing with oppositely motivated stakeholders (I1). (C. Conrad, 2006) encourages the perspective of integrating the project into the management as an opportunity and not as a threat.

Inclusion of legal and ethical guidelines should also happen in this stage, but has its focus in the upcoming stage 5 (Fraisl et al., 2022; IFRC, 2017; Minkman, 2015).

4.1.5 Stage 5: Data Management

Legal and ethical laws, guidelines, and standards especially in terms of privacy and data security need to be respected. This also includes taking into account informal, community and cultural practices during all phases of data management (IFRC, 2017). These phases encompass the planning and design, the collection on site, the transmission, storage, Quality Assurance (QA) and Quality Control (QC) as well as subsequent analysis, presentation and dissemination of the outcomes (Fraisl et al., 2022).
All of these phases need to match the capacities of the organisation and of the contributing participants (IFRC, 2017; Minkman, 2015). Furthermore, all practices should focus on the end use and application of the data in supporting decision-making and follow the principle of data minimisation (EDPS, 2023; IFRC, 2017; Minkman, 2015). In this stage, the planning of the data management procedures enters its detailed phase, is based on the established structure in Stage 3 and results in precise methods, techniques, protocols and scripts. The methods should be simple, well-designed, peer-reviewed and standardised, while being fit for purpose (Fraisl et al., 2022; IFRC, 2017; Silvertown, 2009; Whitelaw et al., 2003). QA and QC procedures should ideally be integrated in every phase and follow the same high standards as the methods (Fraisl et al., 2022; Mackechnie et al., 2011; Sharpe & Conrad, 2006; Silvertown, 2009). Financial and human investments and resources need to be specified and parameters about the technical infrastructure such as architecture, storage, analysis, transmission and collection protocols and methods need to be defined (Fraisl et al., 2022; Sharpe & Conrad, 2006). For data collection "the least intrusive and most cost-effective method available" (p.27) is recommended (IFRC, 2017). The applied tools for data collection and transmission need to meet the available resources and technical abilities of the participant on site (IFRC, 2017; Minkman, 2015). Network coverage should be taken into account when implementing SMS or other remote devices but the IFRC (2017) notes, that "it is now increasingly rare to have absolutely no network access, but a bicycle messenger or another local communication system will also work" (p.26). An automated, technical remote solution should be the preferred solution, but simple SMS and phone calls directly to the relevant manager or via traditional communication networks can also work, especially in cases where transmission speed is not of utmost importance (Gualazzini, 2021; IFRC, 2017). The requirements for data storage solutions include secure storage, good maintenance options and high up-times. The position of the servers and the ownership of the data can lead to disagreements with local stakeholders and should be well communicated (I2). Before the analysis of the data, robust QA and QC measures should ensure high quality of the collected data (Fraisl et al., 2022; Sharpe & Conrad, 2006). The integration of other data sources for information triangulation is recommended. The analysis is the centrepiece of the data management and should follow the objectives of the overall project. The outcomes should be made publicly available unless prevented by security or privacy concerns (ESCA, 2015; Sharpe & Conrad, 2006). The type of presentation can show aggregated data, but should take into account the information

needs of decision-makers. As with the issue of ownership of data, the procedures for sharing and presentation can also lead to disagreements and need to be managed sensitively (I3; IFRC, 2017).

4.1.6 Stage 6: Evaluation & Iterative Improvements

Evaluation is an ongoing effort and should be considered at all phases of the project. The structure of the project should allow for evaluation procedures and subsequent implementation of the derived recommendations at all design stages and during operation (Fraisl et al., 2022; IFRC, 2017). Success metrics as well as the response upon those need to be defined and agreed upon before the implementation of the project (Fraisl et al., 2022; Gualazzini, 2021). The ninth principle of ESCA (2015) states, that "citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact" (principle 9). Underlying structures, practices and efforts can thus be configured and adapted into a more effective and efficient design and process. The integration of these assessments thus helps to progressively improve the use of data by decision-makers as well as the methods used (Fraisl et al., 2022).

4.2 Project Requirements Catalogue

The Project-Requirements-Catalogue (PRC) extends the process-oriented structure of the SSDR by listing, structuring and grouping important information requirements in line with their inter-dependencies. The catalogue of project requirements presented here is divided into four groups of information that include Minkman's 2015 derived goals and sub-goals and follows the layer structure of the SLMC. For each goal, products along with their required activities have been defined in line with the above roadmap.

The first group **Knowledge Base**, see figure 4.2, contains everything that should be known for the project. It thereby serves as a knowledge base being filled throughout the above-mentioned stages. Activities are primarily about identification and information collection. The second group **Groundwork** contains everything on which the actual implementation of the project must be based on, see figure 4.3 and 4.4. It includes the goals *Awareness Raising, Public Education and Policy Development*. The first two goals relate to products of information and sensitization measures for the target community, contributing volunteers and involved stakeholders. Activities focus on consulting with local elders and key stakeholders, and subsequently informing and raising awareness among the entire community before the project starts. The third goal, *Policy Development* is about IWRM measures, required products and their development. The activities aim to embed these into existing local management practices and procedures through identification and agreements with all affected and involved stakeholders. In order to facilitate this, new policy developments and adjustments may be required which overlap with the third group of **Innovations**, see figure 4.5. This stage is important, as "there is no one-size-fits-all approach" (Fraisl et al., 2022, p. 2) and new developments of suitable and scientifically sound

methods to meet specific challenges of the project tasks will be necessarily in nearly every application to some extent and are summarised under the goal of *Method Improvements*. The last group **Management** contains all that needs to be done to successfully develop and implement a CS water source mapping and monitoring project, see figure 4.6. The goal *Management Improvements* is further subdivided into products that are initially necessary once, recurrently and products that are required to embed the project in the context. The focus of the activities is on making decisions, developing procedures based on the **Groundwork** and **Knowledge Base** groups and implement developed methods from the **Innovations** group.
The order of the sections does not necessarily reflect the processing order but rather indicates dependencies whereas e.g. not everything need to be known in order to proceed with method development. The same applies to the order of products and activities (from top to bottom). However, to stay in this example, everything that, directly or indirectly, influences or is influenced by this certain method should be known. Therefore, stages 1 and 2 of the SSDR should be completed before proceeding further with this catalogue in order to have a profound understanding of the local circumstances and their interconnectedness and interdependences.
The following sections briefly reason and describe the overall idea and content of each group. The activities are mostly already outlined in the above-described SSDR, therefore the focus lies on the products of each goal.

4.2.1 The Knowledge Base: What needs to be known

This Knowledge Base covers information and knowledge of all stages and is sub-divided into multiple products that each cover certain aspects of the project. The products (A), (B), (C) and (D) cover the baseline information of all stages. (A) includes information obtained in Stages 1 and 2 and, if this project is developed under an EAP, also the information from the overarching EAP assessment and feasibility study can be integrated. (B) is the repository for all information related to the Citizen Science community and participant management, (C) covers all topics of data management and QC and QA integration and (D) relates to evaluation and improvement procedures. These products consciously resemble Stages 4, 5 and 6, and should be included right at the beginning of Stage 3. The structural basis for each of the subsequent stages is laid in Stage 3, and by bundling the information from the beginning, follow-up in the subsequent stages is simplified and streamlined.

Products (E) to (H) are more specific for the mapping and monitoring of water sources in an FbF context. (E) integrates all information for the first phase of mapping and collection of key information on each water source including corresponding methods, while (F) includes all knowledge and methods on regular indicator monitoring. Together, this information enables actions on products (G) and (H). All potential AAs are first collected in product (G) and then narrowed down to those that can be triggered by thresholds related to water sources. The information about these thresholds along with triangulation data for the respective triggers is comprised in product (H).

FIGURE 4.2: The Knowledge Base. Source: Own representation.

4.2.2 The Groundwork: What needs to be built on

The Groundwork relates to everything, that needs to be in place, before the actual mapping and monitoring of the water sources starts. It is about giving the community all the information and knowledge to decide, manage and act primarily on their own, ideally only limited by the available physical and financial resources. Important is, that knowledge should not opposed on the communities but rather developed in close cooperation with the affected actors, their knowledge and practices. The first product (A) of the goals *Awareness Raising & Public Education* (see figure 4.3) is about gathering and then providing all the necessary background information to the community in order to allow them to make profound and informed decisions and contributions. Based on this, product (B) summarizes activities to address misunderstandings, reservations as well as expectations and concern handling. For this, the early involvement of community leaders or elders may be beneficial (I1). Product (C) refers to the sharing of information gathered in other phases with the community to keep their knowledge of prevailing and evolving circumstances up to date and to enable informed decision-making. In order to act on the information, product (D) summarizes the identification and transfer of information about water management and saving opportunities. Product (E) highlights the consideration, that even a single community is not homogeneous and that various groups with different interests exist within. Knowledge and measures to account for this are collected under this product.

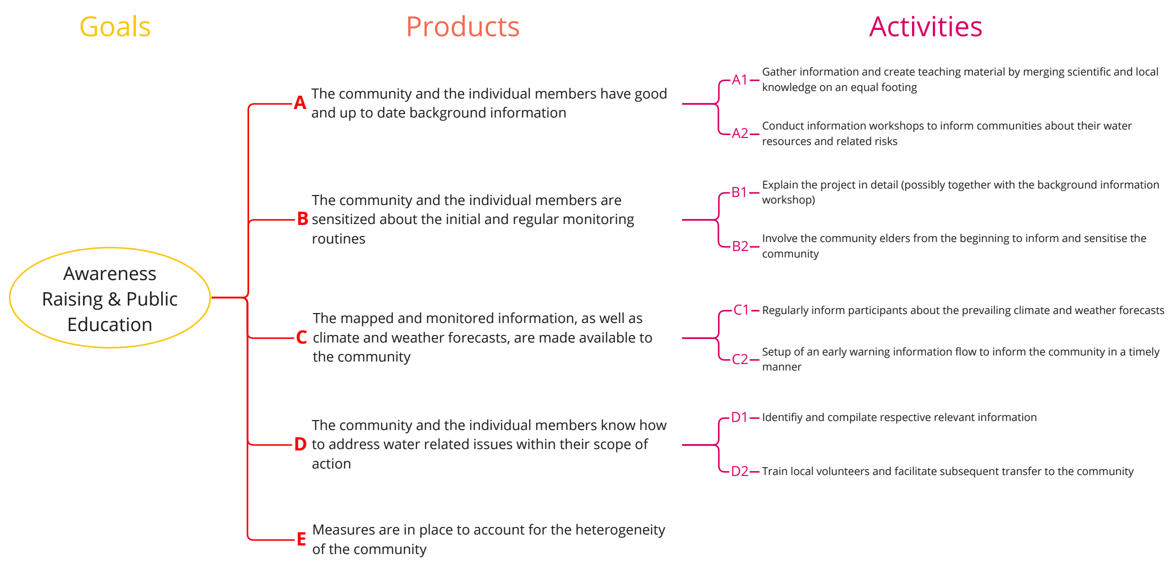

FIGURE 4.3: The Groundwork: Awareness Raising & Public Education. Source: Own representation.

Products A to E of goal *Policy Implementation*, see figure 4.4, represent Day's 2009 light community-based IWRM framework. The framework starts with the products (A) & (B) by identifying and assessing prevailing circumstances and requirements. From this, community water usage targets are derived and agreed upon in (C). Management guidelines, and prioritisation plans are pre-defined and implemented in products (D) and (E). Product (F) goes beyond the framework and addresses measures related to data security and privacy.

FIGURE 4.4: The Groundwork: Policy Development. Source: Own representation.

4.2.3 The Innovations: What needs to be invented

New innovations may be required to successfully achieve the project objectives under the given conditions and in the given context. These developments are grouped separately because the development of appropriate, scientifically sound and context-aware methods can require a great deal of financial, material and human resources and should therefore receive specific consideration. In addition, the development of new methods is often a separate process that runs alongside the actual design and implementation efforts. However, there are now also many projects, guidelines and frameworks from which experience and best practices can be transferred. The developments can therefore also be an amalgamation of the old, tailored to new circumstances.

The products represent potential areas of such required innovations or adaptations. These can include areas of the initial and regular data collection, transmission, storage and analysis as well as, the determination of suitable thresholds, and their categorization for respective triggers.

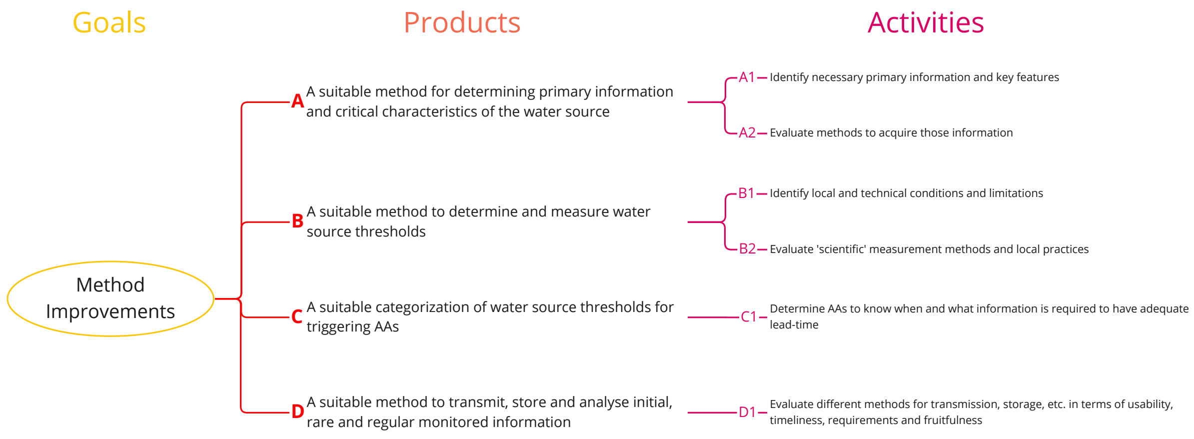

FIGURE 4.5: The Innovations. Source: Own representation.

4.2.4 The Management: What needs to be done

The group around management tasks is primarily concerned with the initial processes and responsibilities at the start of the project, tasks that need to be done regularly during operation, and specifications for solidly embedding the project in prevailing processes and practices. These tasks are about evaluating and processing identified and collected information to develop and make decisions about what elements, practices or structures to implement. The initial areas of concern (A) range from handling specific context related circumstances, to the development of training materials and evaluation procedures. Activities contributing to regular required products (B) are mostly concerned about providing training and supervision and implementing improvements derived from evaluations and feedback. Product (C) includes both initial and ongoing tasks, but is focused on embedding the project in the local context. It addresses the implementation of the *Groundwork* on community level and its integrations into prevailing local, regional and national structures, practices and stakeholder networks to make it relevant for decision-making.

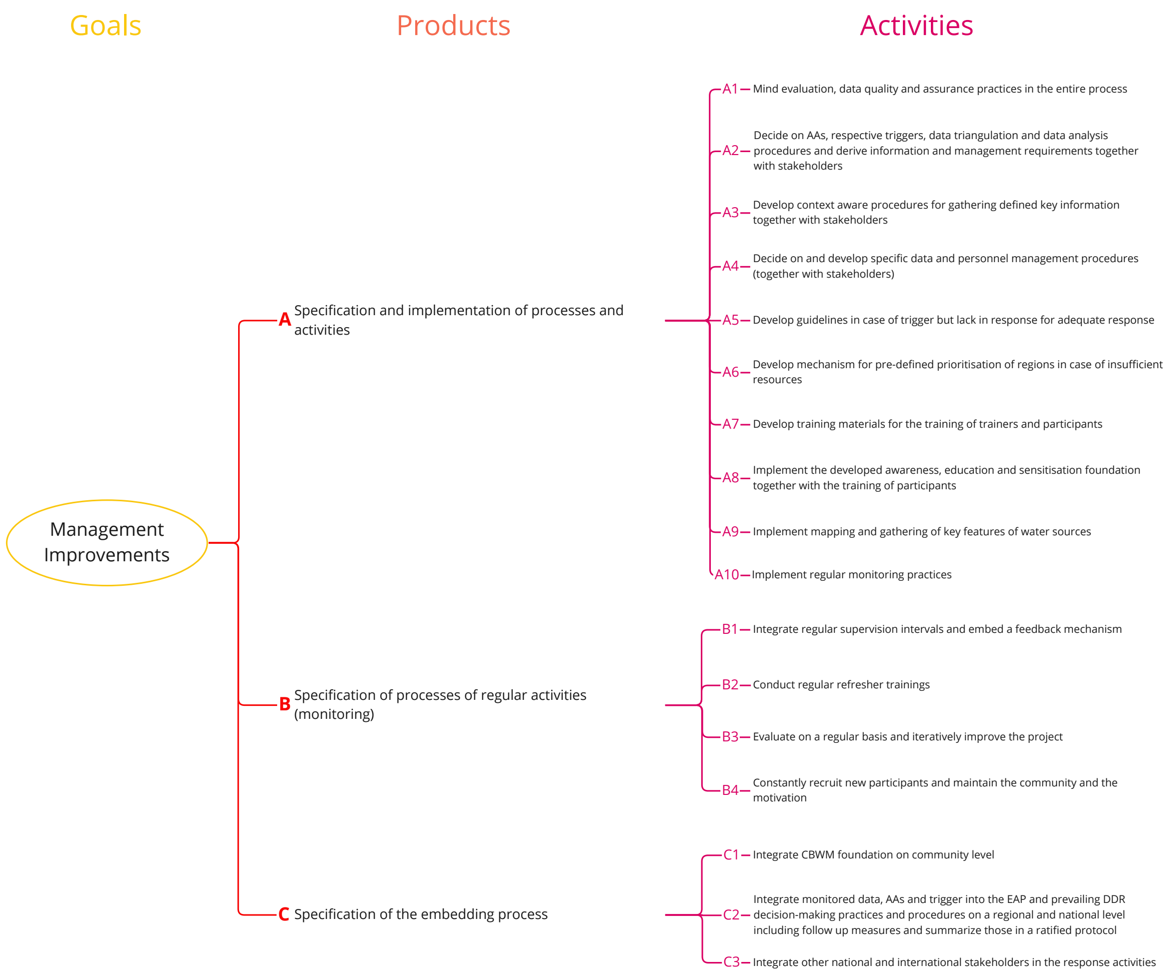

FIGURE 4.6: The Management. Source: Own representation.

4.3 Application: Focus Somaliland

In this part, by applying the roadmap and project requirements described above, the second research question of this thesis is tackled in order to ultimately achieve the overall aim of the research. Therefore, the findings in this section are primarily geared towards identifying and implementing adequate water level monitoring of the water source type of berkads in order to trigger respective Anticipatory Actions. The third stage is structured following the project requirement catalogue. The Stages 4 to 6 refer their findings to the catalogue. However, because of their specific foci, these stages are not structured according to the catalogue. The above already displayed tree-diagrams can also additionally be found in the respective GitHub repository in Appendix A. This provides the reader with a simultaneous reference option, as the products and activities will only be mentioned by their abbreviations and not by their full name, to enhance readability. In the following, the gained information of the interviewees of the project leader of the FbF approach in the SRCS (I1) & (I1.2), the CBS project manager of the Norwegian Red Cross (I2) and the CBS manager on the Somali side (I3) are integrated. The interview with I2 was conducted in German, therefore only quotations of meaning are given.

4.3.1 Application Stage 1: Context & Problem Identification

The brief water source data analysis along with given context, resource restrictions, stakeholders and comparable projects as well as problem and goal statements of the interviewees are covered in this first stage. It also builds on the preceding case study area section 2.5 in chapter 2.

The current drought and water scarcity situation in Somaliland has now lasted five years and has greatly impacted the water sector in Somaliland in terms of quantity and quality (I1). I1 describes the current crisis as *"huge and response activities are being overwhelmed by the need"* which will lead to *"commercialization and overpricing of fresh water"* further exacerbating the situation. This was underlined by I3 who describes the current water situation of the rural population as *"whatever source of water they can find is what they have"*. I3 further mentions, that the people sometimes *won't have enough water to wash their hands"* or for other necessary things and that *"they [then] don't think of what kind of water they can get, whether it's bad or something like that"* but only focus on having at least something to drink. Increased water shortage because of bad quality was also reported in the literature, see section 2.2.3. Water can potentially be contaminated at all stages of the water collection process, from the initial abstraction of water, through transport and storage, to the use of the water (I3). Water quality is difficult to assess on site, as the colour is not a good indicator and other parameters can only be determined technically which requires equipment and special training, which is presently not feasible (I1, I3). Furthermore, I3 confirms the reports in literature that contamination of water in berkads, through their shared use with animals, can happen even before water withdrawal. This depends very much on the construction method and how it is used, compare figure 2.10 of unimproved, open, and improved berkads in section 2.5.2. The rehabilitation as well as training how to adequately use a berkad are already activities of the SRCS (I3) and besides the water quality, the quantity also depends on the kind of construction and of withdrawal. According to I3, supply period can

range from one month to half a year, so information on these parameters is crucial for estimating the potential duration of supply (I3).
Water monitoring and management is not seen as a problem in urban areas as there is an agency responsible for water supply but the problem is primarily located in rural and nomad areas, where 70 % of the people live, according to I3. Republic of Somalia (2021), on the other hand, estimates an urban and semi-urban, sedentary population rate of 53 %.
The selection of beneficiaries for response activities of the SRCS are currently conducted on the basis of a preceding joint priority setting with the government. This prioritisation is based on *"assumed vulnerability per community based on Number of Internally Displayed Person (IDP) camps in the area, number of women headed families, predicted IPC classifications etc."* (I1.2). Anticipatory Actions have not been implemented due to the *"already prevailing crisis"* where the *"needs are [already] dire and the current SRCS's focus is on response mechanisms to address the already visible impacts of drought"* (I1.2). Thus, the overall *"end goal [of this project] will be to counter water shortages"* (I1) proactively but *"there has been any actions yet due to the fact that there is no water monitoring and trigger mechanism in place"* (I1). The monitoring was itself hampered by the fact that *"Berkads location data is currently missing"* (I1).This statement coincides well with the experience of the current project team working on the EAP implementation that SWALIM datasets are poor and OSM is hardly available. (EAP project team, personal communication, 04.03.2022). The evaluation of the available data sets also led to this conclusion.
Table 4.1 shows all available data sets of water sources in Somaliland, provided by SWALIM.

TABLE 4.1: All currently available data sets for water sources provided by SWALIM in Somaliland. Data Source: SWALIM (n.d.) and SWALM (2023)

Year	**Name**	**Total**	**Berkads**	**Boreholes**	**Dams**	**Dug Wells**	**Springs**	Other
2018	Strategic WS	1792	50	357	319	853	163	50
2019	Surface WS	1210		357		853		
2020	Strategic WS	3014	218	885	185	1422	245	59
2022	Strategic WS	685		490	41	138	16	
2023	SWIMS Dashboard	3648	217	1339	225	1547	261	59

The spatial distribution of the datasets across Somalia is relatively balanced, with focal points in the regions with many or larger settlements. Based on the SWALIM settlement data set, there are currently 2,123 settlements in Somaliland. These settlement data are mostly from the years 2002 and 2006. The total number of water sources varies greatly between all datasets. The timeliness of the data also has a wide range, from relatively few pieces of data from 2019 in the 2020 dataset to data from the 1980s in the same dataset is much represented. The 2022 dataset misses information about timeliness altogether and the other datasets all have many blank entries as well. Furthermore, many water sources are labelled as 'abandoned' or 'non-functional', e.g. in the 2022 dataset those are 147 out of 685.

The data sets are fed by many sources and institutions e.g. FAOSWALIM or other UN organisation, MoWR, NADFOR and other NGOs which constructed some water sources in some communities (I1). These institutions, along with the community and their elders, local government representatives, SRCS and their volunteers and private berkad owners are also the potential stakeholders of the mapping and monitoring of berkads. Here, I1 notes, that besides the SRCS, the MoWR, NADFOR and the constructing NGOs are the most important stakeholders. The MoWR and NGOs have the technical expertise in construction, rehabilitation and monitoring and NADFOR has a comparable community level programme for monitoring *"livestock body condition, market prices as well as weather variables"* (I1).
Other comparable programmes exist from OCHA, BRCiS and the CBS programme run by the Ministry of Health, the SRCS and the NRC. While these projects may broadly be comparable in terms of focus on AAs, none of the Interviewees know of a project that conducts similar things to this works aim (I1, I2, I3). I2 also suggests that the projects are close enough to each other to pass on experiences and recommendations, e.g. from the MoH to the MoWR, in order to overcome initial scepticism and reluctance.
Challenges, limitations and requirements are mentioned in areas of privately owned berkads, community expectation handling and the dissolution of misconceptions as well as potentially already overstretched SRCS staff and volunteers (I1). I1 mentioned, that private owners of berkads may prevent the volunteer from gaining access to their berkad which would result in less information on the one hand but also in tension in the community on the other. Giving information from the community to someone else may also generally require some explanation (see I2). Furthermore, some *"information on past details per particular geographical areas"* (I1.2) can be difficult to access, as *"Somalis are highly mobile communities"* (I1.2). The monitoring could furthermore develop *"huge expectations from the communities as there is the ongoing drought. Whenever there is monitoring of resources, communities believe this should be followed up by instant aid"* (I1).
Addressing some of the challenges mentioned above, the *"community elders should be engaged before the start of the mapping and monitoring as they will help dispel misconceptions about the project"* (I1) and the *"ministry of water resources should be in the loop during the entire project duration"* (I1).
Nonetheless, the *"community and SRCS goals match as both focus on closing the knowledge [gap] currently existing"* (I1) in regard to the number, status of ownership, location and capacity of the berkads per community, district and regional level. This will *"inform decision-makers on the priority areas to focus on"* (I1). Therefore, I1 expects that this information from the site triangulated with weather forecasts can help to form robust triggers to take appropriate and informed Anticipatory Actions before critical water levels are reached.

4.3.2 Application Stage 2: Feasibility Assessment

In this stage, the practical capacities, and applicability and suitability of the CBM and MCS approach for community-based water monitoring were examined in this context. The SRCS has 249 paid employees, of which 30 work in the risk management and Anticipatory Action domain and an additional 1500 volunteers are "evenly spread"(I1) across the country. I3 emphasises the *"good relations and good reputation"* that SRCS has within the communities, making

them *"one of the most trusted organizations in the country"* which helps to do programs at community level. The *Feasibility Study on Potential Use of Forecast-based Financing (FbF) for SRCS* (SCRS, 2022) recognizes a *"strong national organization"* (p.44) with a *"strong volunteer base at community level"* (ibid.) that *"provides monitoring and hazard warning capacities"* (ibid.). Furthermore, *"highly skilled and experienced management staff at coordination and Branch levels"* (ibid.) is stated. Nonetheless, *"minimal domestic resource mobilization"* (ibid.) and a *"lack of meteorological, geo-spatial analysis, data management and IT staff"* (ibid.) has also been detected.
This lack of resources and digital capacities was addressed in the CBS project by the NRC and their NYSS platform, see section 2.4.3. Generally, CBS is *nothing new in itself and often used in health contexts* (see I2). CBS in Somaliland started in Burao in 2018 with 75 community volunteers, as cholera had broken out in the same region in 2017 (I3). After the pilot was successful, CBS has since been extended to all regions but *"SRCS only focusses on hot spot areas where they expect outbreaks to happen"* (I3). This development took place over the course of a year with much feedback from the SRCS and NYSS is now *"very effective and very supportive"* (I3). The Ministry of Health (MoH) was and is *constantly in the loop to decide together what, how, when and who* and could gain good experiences with NYSS over the years (see I2). By now, NYSS is well embedded in the local conditions and *"mobile teams [...] can be deployed immediately within hours so they can do the response"* (I3) in collaboration with other partners such as the *"government, MoH, WHO, and other sister RCRC organisations"* (I3).
I2 mentions, that the monitoring of water sources *would fit well thematically, because it [low water levels and poor water quality] is a health risk* (see I2) and that although it would require some adjustments and considerations, it would organically expand technical expertise and functionality as it is not *radically new* (see I2). Besides NYSS, being methodologically similar but different in thematic orientation, several other projects could be identified in literature, that are oriented towards the same topic but differ in their implementation and operation procedures (compare section 2.4.3). It can be deduced from this that CBM and MCS can in principle be applied to the thematic issue. Furthermore, Fraisl et al. (2022) themselves describe approaches that focus on the "in situ monitoring" of water resources and at the same time benefit the respective participant as adequate for the use of a Citizen Science approach. SRCS does not pay their volunteers but provides training and covers travel expenses as incentives. Moreover, volunteers are generally well regarded and are selected by the community itself. Intrinsic motivation is therefore present (I2, I3).
(Fraisl et al., 2022) prerequisites are thus fulfilled, and the key objectives of the RCRC's CBS preliminary assessment can be answered positively. The task is applicable within a CS approach and the SRCS is an adequate partner with sufficient capacities and experiences to implement the mapping and monitoring approach. The project can thus be further developed in Stage 3.

4.3.3 Application Stage 3: Structure & Design

This stage is grouped into the four project requirement groups and lays the structure for the coming stages. The overall project aim to counter water shortages proactively is majorly hampered by missing information about the water source type berkad. Therefore, up-to-date information on water sources in Somaliland is needed. In particular, there is a lack of information on the important Berkad water sources (compare Stage 1, section 4.3.1). Therefore, the focus of this project will be on gathering information about this specific water source type (I1). See chapter 2.5.2 for further information about this water source type. I1 also named and chronologically ordered the most important fields of action that need to be realised in order to achieve this goal:

1. Volunteer briefing and training
2. Community sensitization
3. Locating and gathering key information about berkads
4. Determining respective Anticipatory Actions
5. Determination of the water level thresholds
6. Monitoring of the water level
7. Triggering AAs based on pre-defined threshold

I1 highlights the importance of the actions 2, 3 and 7 as critical for the overall success of the project. For the design stage, I1 emphasises the determination of the threshold, Anticipatory Actions and respective trigger. As I1 draws his judgement from his work as the local program manager and coordinator, this project followed these priorities during the design process. This process is grouped by the project requirement catalogue in the following. The structure of each group follows the order of the products and respective activities, emphasis was given to the activities which contribute directly to the above mentioned priorities. To minimise repetition in the scope of this work, already covered areas are only referred to and not again outlined in detail.

The Assemblage: Knowledge Building

The majority of the activities of product (A) were already covered by previous stages and chapters. (A1) was extensively outlined in section 2.2. (A2) and (A3) were covered by Stage 1 (section 4.3.1), 2 (section 4.3.2) and the case study section 2.5. (A4) on the one hand will influence decision-making in the SRCS but further integration into e.g. governmental procedures could not be covered by this work. Activities A5 and A6 could also only be touched upon, but especially the topic of integration of local knowledge holds a lot of potential, see 2.2.4.
Product (B) could partly be covered by Stage 2, section 4.3.2. Results so far suggest that the network and individual volunteers are adequately trained, motivated and managed for the monitoring task, which laid the basis for Stage 4. In terms of adequate data management (C),

feasible technical solutions could be identified from other projects and their practical applicability was demonstrated by the successful CBS program of the SRCS (C1). Further exploration in Stage 5 was thus possible. (D) current evaluation and improvement procedures could be identified and are further described in Stage 6.
(E1) initially important information about each berkad is summarized in figure 4.7. This compilation is based on section 2.5.2, and knowledge of I1, I2, and I3. The left, bold side are the information highlighted by the interviewees and summarize the key information. The right side displays information, that may be nice to know for further analysis, but is not regarded as critical for this project.

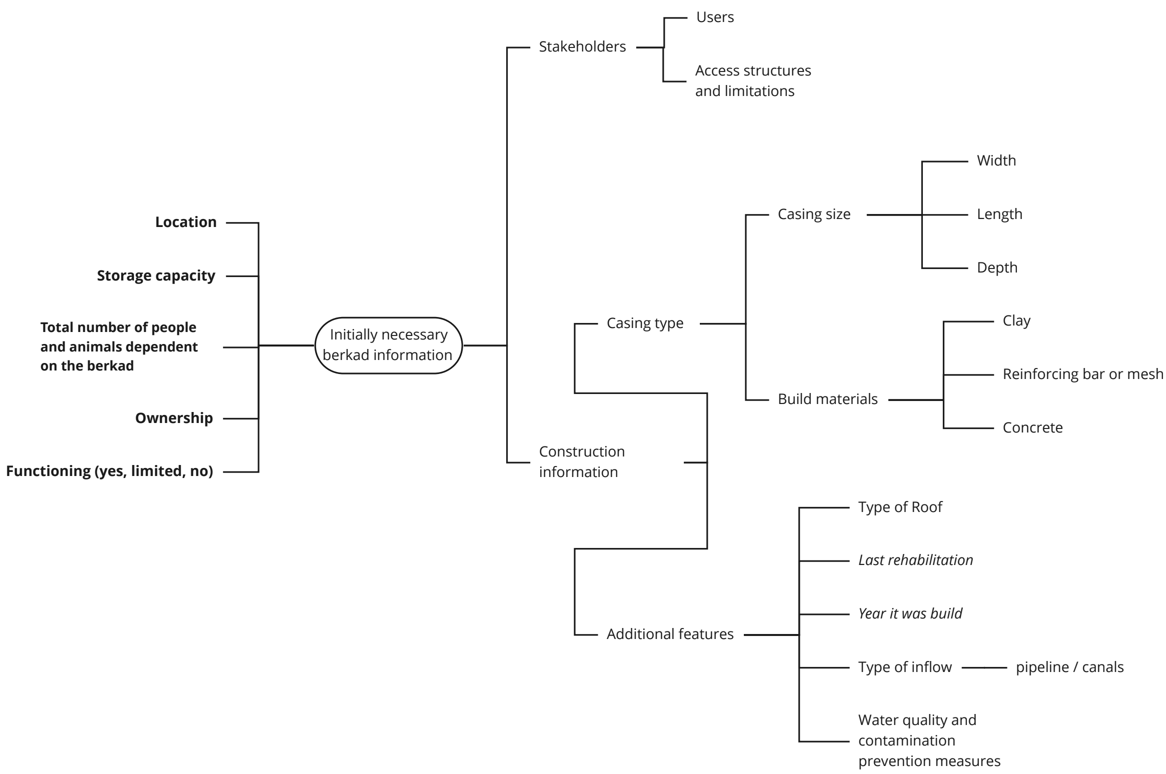

FIGURE 4.7: Key Features of a Berkad. Source: Own representation.

In terms of (E2), location, storage capacity and construction information need to be identified initially and might need to be updated when e.g. the berkad is rehabilitated. These information will be gathered by SRCS professionals and therefore does not need to be included in the regular monitoring routine. (E2) a report about the condition of the berkad may only be necessary once a year (I1.2) while the number of people and animals may need a weekly or monthly reporting interval, depending on the fluctuation strength (I1.2). This information should be kept comparatively up to date, as the high mobility of Somalis means that this number can change relatively regularly and has a great influence on the amount of water abstraction (I1.2).
(F1) the water level of the berkad was named as constantly changing indicator which should be monitored in a weekly interval (I1.2). The realisability and adequacy of this reporting frequency was also supported by I2 (F2). (F3) The data sets for the data triangulation are adopted

from the overarching EAP and have not yet been determined at the time of writing.
Potential AAs that can be triggered in correspondence with a the surveyed information and certain water level threshold are listed below (G).

- Informing about water rationalisation and saving opportunities
- Information dissemination of climate and weather forecasts
- Distribution of drought-resistant crops
- Rehabilitation of berkads before the rainy season
- Compensate private berkad owners to access their water
- Timely distribution of cash to enable communities to buy and stock fresh water
- Timely distribution of water purification tablets
- Water trucking

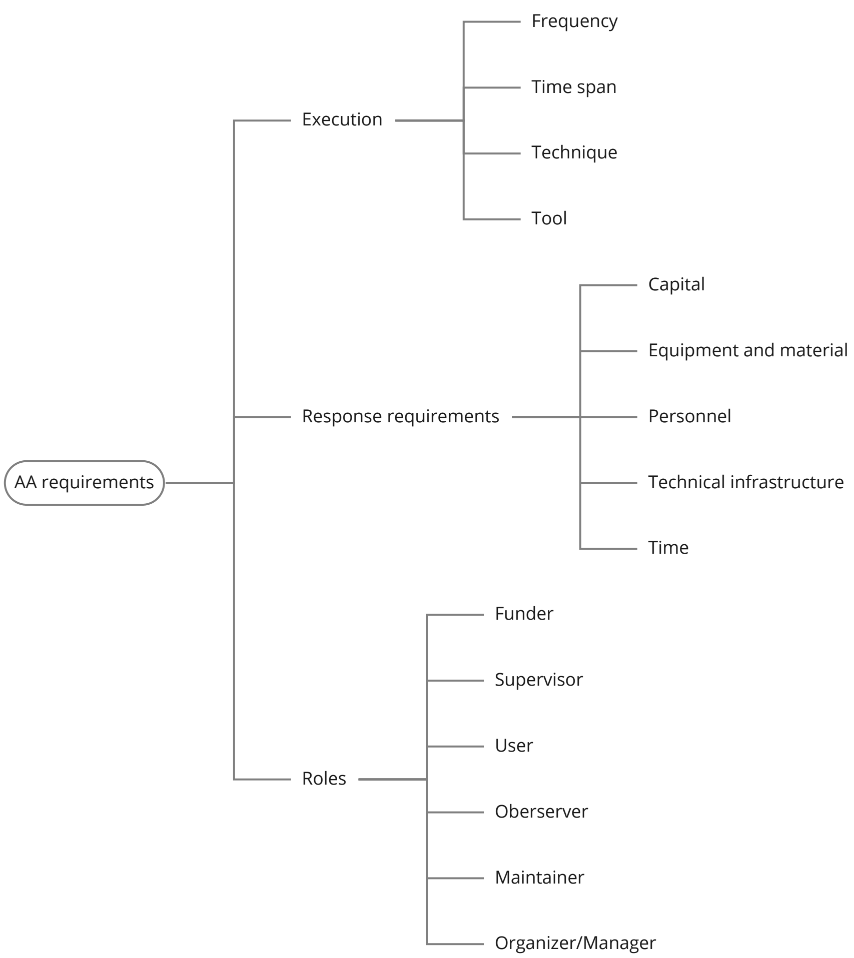

FIGURE 4.8: Requirements for Anticipatory Actions. Source: Own representation.

Raising awareness and information dissemination need to be the foundation of this, see Groundwork 4.3 (I1.2). The distribution of drought-resistant crops and other agricultural related actions need to be coordinated with the Ministry of Agricultural Development (MoAD). The rehabilitation of berkads before the rainy season needs to be related to seasonal triggers as this actions will help to store available rain water and won't directly help in times of acute water shortages. I1.2 notes, that the involvement of private berkad owners *"could be limited as they are more concerned about their business models i.e selling of the water and preserving their berkads than being part of the overall response/Anticipatory Action mechanism"*. Nevertheless, I1.2 sees potential in working with private berkad owners and suggests e.g. the rehabilitation of their berkads *"in return for their involvement in response and Anticipatory Action activities"* as viable AA. The distribution of cash is a widely applied AA in FbF projects and can help in many cases. Distribution of water vouchers is an alternative to direct cash and has already been used successfully in Somaliland, see section 2.5.5. Water purification tables and information for waterborne disease prevention are already disseminated by the SRCS volunteers together with hygiene and health promotion activities but could be better targeted by more timely and localised information (I3). The required lead time, tangible and intangible resources, information requirements and involved roles (G2 & G3) of these AAs are illustrated in figure 4.8.

The list of AAsin figure 4.8 is not comprehensive and needs to be refined for each AA, which is illustrated in figure 4.9 for the AA *water trucking*.

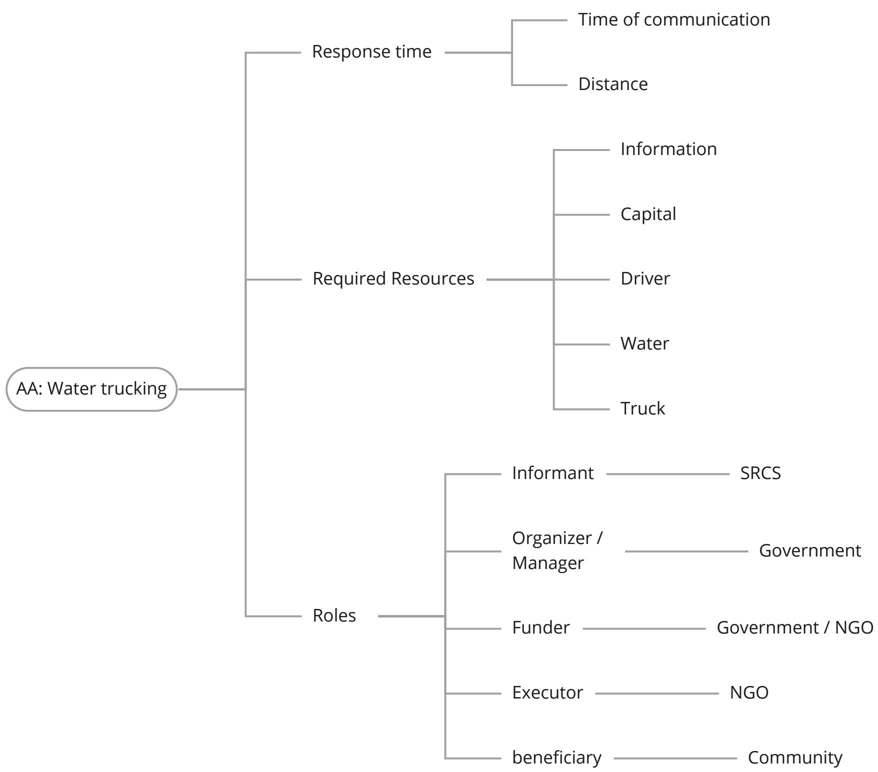

FIGURE 4.9: Important Information about the Anticipatory Action of Water Trucking. Source: Own representation.

Water trucking is a common measure to cope with acute water shortage in Somaliland (I1.2, I2). Information for water water trucking comes, thus far, from SRCS assessments, from the community themselves, government agencies, FSNAU or other NGOs (I3). This type of information transmission can be timely and may be incomplete. The water transport itself can take a long time and can be relatively expensive due to the distance and high demand (I1, I3). It is financed by various stakeholders, including the community themselves and private donors (I3). Self-financed water trucking is especially common in the beginning of the initial phase of drought but if the people cannot afford to buy water any more and their livestock becomes weak or dies, *"[...] this is the time they talk to the other NGOs or the government and say we need support [...]"* (I3), which is often already too late for proactive measures. Currently, the following prioritisation of water trucking by the regional and national stakeholders is primarily based on government decisions and focusses on the most vulnerable communities (I3). This decision-making process could not be explained in more detail by (I3) other than it is a *"joint effort by all stakeholders"*. The SRCS does not truck water themselves (I1.2).
(H1) potential water level thresholds were suggested by I1.

- Empty (no water at all)
- Critical (1 day of water supply remaining)
- Low (3 days of water supply remaining)
- Middle (5 days of water supply remaining)
- High (full capacity)

I1 further specified the *Low* category to trigger the AA of *water trucking* (H2). These water levels either require local knowledge about how long the water will last or require the analysis of the exact or categorized water level with the known berkads capacity. The first option would outsource the triangulation of available resources and amount abstraction to the communities predictions. I1.2 notes, that *"these kinds of predictions are good as communities usually have their own control measures to ensure equitable distribution of water e.g. how many containers per family etc. The berkads are usually locked to ensure there is controlled access to the water stored"*. The second requires good information about the berkad itself and a feasible method to interpolate this with the regularly measured information. Gualazzini (2021) however, proposed more seasonal focussed threshold levels for berkads, see chapter 2.5.5. (H3) the short-term thresholds may be feasible to short-term and fast AAs, whereas seasonal information may trigger AAs such as the rehabilitation of berkads and information campaigns.

The Groundwork: Laying the foundation

Volunteer briefing and training together with following sensitization of the community are the first two measures that lay the foundation for the implementation of this project (see section 4.3.3, I1). In terms of raising awareness and public education, see figure 4.3, (A1) major challenges could be identified in community expectation handling and the involvement of private berkad owners (I1, I2). I1 suggested, the early engagement of community elders to address

community internal issues and the continuous involvement of the MoWR for organisational and stakeholder management. Awareness-raising activities and dissemination of information may include knowledge of water quality improvement techniques, water conservation strategies, early warnings and a detailed explanation of the reasons for regular water level reporting before the start of the project (I1, I2). It also needs to be *communicated, discussed and decided beforehand* (see I2), what happens in cases when thresholds are reached but no response is possible. *Otherwise, it could fall back negatively on the SRCS and the Volunteer* (see I2). Furthermore, I1.2 highlights the importance, to establish *"a robust feedback and complaints mechanism that ensures communities can easily relay their feedback"* right from the start. The development and implementation of products (A2), (B), (C), (D), and (E), see figure 4.3, must happen in close collaboration with local stakeholders and were thus out of scope of this work. Nonetheless, the work with the community should be fruitful as their goal to *"ascertain whether these water bodies are able to withstand the demand during drought periods"* overlap with the project goals (I1).
In terms of policy implementation (see figure 4.4), the integration of the light IWRM framework developed by Day (2009) was presented in section 2.4.3 and needs to be further discussed with local stakeholders and interrelated with prevailing procedures.

The Innovations: Developments & Improvements

Besides the identification of a way to integrate IWRM practices into local procedures and structures, more technical solutions were also required to be developed or adapted. (A1) important primary information about the water source berkad could be identified by the method of expert interviews. (B1) and (C1) could be identified through interviews and literature analysis, where (B1) will either be a kind of categorised yardstick or a local estimation based on experience or a combination of both. However, a thorough assessment and subsequent adjustment of the practical suitability will only be possible in a pilot study. This is especially true for their evaluation (A2) and (B1). Several data management methods could be identified in literature, see sections 2.4.2 and 2.5.5, and applied in practice by other projects see sections 2.4.3. The desk-based evaluation (D1) has shown advantages and disadvantages for all potential methods, from simple to very dedicated implementations, thus allowing an informed decision in the coming chapter. Building on this, a first draft of possible SMS codes could be developed for (1) a data based application and (2) a more local knowledge based version:

1. *Weekly* : # *Water Source ID* # *Water Level* # *Functioning / Accessible*
2. *Weekly* : # *Water Source ID* # *Predicted Supply Duration* # *Functioning / Accessible*
1. *Monthly* : ## *Water Source ID* # *Number of dependent people* # *Number of dependent animals*
2. *Monthly* : ## *Water Source ID* # *Daily Amount of Withdrawal*
1. *Annually* : ### *Water Source ID* # *Water Source Condition*
2. *Annually* : ### *Water Source ID* # *Water Source Condition*

Hereby, the different report types are marked with the different number of starting '#'. The *Water Source ID* may be a composite of regional, district, and community identifiers along with a specific water source number. The *Water Level* or *Predicted Supply Duration* refers to the amount of water that is still available and the *Functioning/Accessible* code may indicate if the source is functioning and/or accessible to the community. These two indicators could be combined in one number, as there are only four possible combination possibilities. With this, social and technical aspects could be monitored. The monthly codes relate to the amount of withdrawal and thus takes account of potentially changing demand conditions. The *Water Source Condition* is difficult to limit on one number and more might be necessary as there are many different factors that can influence the condition, see figure 4.7. The number of codes is deliberately confined by a maximum of three codes, as this was the recommendation and limitation by I2, see Stage 5, section4.3.5. The codes may only be seen as recommendations and will need to be evaluated and adapted in the future work.

The Management: Mapping & Monitoring

This last group of the project requirement catalogue comprises activities for evaluation and decision-making on the pre-identified conditions in the preceding sections. Though, due to the overarching ongoing EAP development and no possibility to conduct studies on site, no decision or on site evaluation could be made in the context of this work. Nevertheless, a lot of information and good practice could be gathered and organised appropriately in the presented groups in the previous phases which will greatly facilitate future evaluation and decision-making.

4.3.4 Application Stage 4: Community & Stakeholder

In the context of this project, the community volunteers of the SRCS are the contributing participants. The findings of this section contributed to the knowledge base primarily in areas (A4) to (A6) and (B) and form the basis for the participant and community related products and activities of the *Groundwork* and *Management* group. The volunteers are commonly not recruited by the SRCS in the common sense but rather chosen by the community (I3). Therefore, they are usually not primarily selected on the basis of their education or skills, but on the basis of the community's own criteria (I3). The decision on who becomes a volunteer is generally made by the community committee and their elders (I2). I3 notes that volunteers generally have a *"good reputation in the community"*. *"After the selection, SRCS is doing a small assessment about e.g. reading and writing skills and then provide training to them"* explained I3 in regard to the volunteers. Besides the social prestige, this training is also the primary extrinsic incentive to become a volunteer as the volunteers are not compensated otherwise (I2). Thus, volunteers need to be intrinsically motivated and *"willing to be a volunteer"* (I3). After the training, the volunteers are send back to their communities and start working there (I3). Volunteers are *mostly women as they stay in the community and do not travel as much as men* (see I2). The work includes raising awareness about health and prevention hazards and informing about mitigation measures, as well as directly responding to them and, in the context of CBS, reporting (I3). Currently, in

case of water shortage, volunteers educate people on how to prevent waterborne diseases by providing hygiene and health education and distributing water purification tablets (I3).
Preliminary trainings, supervision and regular refreshers were seen, especially in the beginning, as important and as a great success factor by I2 and I3. In the CBS program, refreshers were conducted in a monthly interval but this is no longer necessary in that frequency as the *volunteers know their business by now* (see I2). Nonetheless, supervisors still validate and clarify reports, e.g. via phone or on-site visits. As already described in Stage 2 (section 4.3.2), SRCS spends a lot of time on community bond building and thus generally has a very good reputation with the communities (I2, I3). This greatly facilitates the information flow and response together with other stakeholders such as the MoH or NGOs (I2).
A selection of other national and international stakeholders were already mentioned in section 2.5.5. The interviewees often mentioned the importance of the MoWR and their early involvement. I2 mentioned, that they had many discussions with the MoH when integrating the CBS project and that these discussions are still ongoing. However, I2 also mentions, that in their recent evaluation, *the confidence in the MoH is not so great*. *Many organisations come to the MoH with their own instruments, methods and goals* which can further complicate the integration of projects and increases the competition. Therefore, I2 started to work with lower agencies instead but highlighted, that for the case of this project, experiences might be transferable from the MoH to the MoWR.

4.3.5 Application Stage 5: Data Management

Data management was first mentioned in the context of Mobile Crowdsensing in section 2.4.2 and more specifically in terms of Community-based Surveillance and NYSS in sections 2.4.3 and 2.5.5. In Stage 2 (section 4.3.2), the implementation feasibility of CBM and MCS was reasoned.
This stage contributed to the *Knowledge Base* in (C) but also influenced the selection of AAs and trigger thresholds, as the data management capacities set the frame for the collection of respective indicators. It was less important for the products of the *Groundwork* but most developments of the *Innovations* group facilitated this stage. The actual implementation and its technical capacities will also strongly influence *Management* in regard to all data related developments and decisions.
I2 stated, that NYSS may be a good fit for the water level monitoring, when the primary orientation is on early warning and Anticipatory Action and not on general data collection. Discussions about the possibility to use NYSS are still ongoing at the time of writing. The potential integration of NYSS, together with its dedicated implementation, makes NYSS the preferred MCS platform for this project and it was therefore further explored in this stage. However, less automated and technical processes such as simple SMS or calls directly to the respective supervisor with manual data entry are also possible and common practice in many CBS projects (I2). The predecessor of NYSS itself was less automated and the evaluation was done with Microsoft Office (I2). These simpler processes are, apart from the higher manual effort, mostly very comparable to the integration with NYSS in the areas of planning, implementation and

evaluation, only less automatized (I2).
I2 mentions in regard to the server location in Ireland and data ownership by the National Society and the location of the servers outside of Somaliland did not resonate well with the MoH and required a lot of communication. The progress made here could also be translated from the MoH to the MoWR.
The method of data collection via coded SMS should also work for monitoring water levels, whereas *one to three codes for regular monitoring should be alright but not more, as more codes make it more complicated and will narrow down the choice which volunteer to take* (see I2). Sending photos would possibly also work with this thematic focus, but would require smartphones and internet connection on the side of the collector. Though, I2 is *not supporting the distribution of smartphones for 'several reasons'*. However, less frequent transmissions with more codes would be possible through further aggregation. Therefore, the regular weekly water level monitoring as well as the seasonal major data collection would be facilitated by this method (I2). Small code explanations in local language and with images would need to be developed to give orientation and reference to the volunteer (I2).
The reports need to be validated and it *should be communicated, that reports will be checked by the supervisor in order to prevent false reports in hope of more water. If this happens frequently, a solution must be conceptualized* (see I2). Despite all of these similarities of the approaches, I2 mentions, that the integration of the requirements of this project into NYSS will be work and that it needs to be discussed who does it and who pays for it.
The data collected within the NYSS platform, could recently be fused with other MoH data sets but that was *challenging and a lot of work* (see I2). This shows, that while the automatic integration with other data, e.g. from the Ministry can be *laborious and complicated* (see I2), it is possible. This would enable the (automatic) triangulation with *"meteorological forecasts and local knowledge"* (I1.2) already mentioned in previous chapters.

4.3.6 Application Stage 6: Evaluation & Iterative Improvements

Evaluation is often referred to as an ongoing effort and the need to structurally integrate it at all stages was highlighted frequently in the above stages. From problem definition, through subsequent conceptualisation and design together with the community and stakeholders involved, to operation with regular training, supervision and feedback on each report, there is an opportunity for feedback and evaluation at every stage of the project (I2, I3). However, concrete measures of success still need to be defined with stakeholders before implementation. An evaluation of the implementation and operation could not yet be carried out, but there were already several iterations and improvements in the design phase, which could be implemented well with the presented framework.
Evaluation practices are also already part of the organisational culture and procedures of the SRCS. This is particularly evident in the monthly meetings with the communities and in the CBS implementation, which includes many feedback, evaluation and monitoring procedures. In addition, all interviewees mention the high investments of the SRCS in communication and feedback processes. I2 states, that *SRCS are no rookies. They know how to communicate as it is a big*

part of their culture.

4.4 Application & Design Summary

The findings presented the development and subsequent application of a community-based participatory water source monitoring framework. The outlined Six-Stage-Design-Roadmap (SSDR) and PRC framework is a new framework adjusted and tailored to settings like the one in Somaliland with the aim of facilitating proactive measures.
The structure of Fraisl et al.'s 2022 SSF has been retained, but thematically expanded by additional guidance, including best practices from the IFRC and the local BRCiS initiative. The first stage explores the overall context, the problem and derives initial approaches to solutions. The second stage assesses the feasibility of the Citizen Science approach in the given context. It goes into more detail, defines goals along with sub-goals and explores the actual possibility and capacities for a successful design, implementation and operation of a CS project. Only when this phase has been successfully completed, the requirements have been met and no *red flags* have been encountered, will the next stages be considered. Stage 3 *Structure & Design* further specifies the previous findings and clearly focusses on the actual required products and activities to reach the goals. Stages 4 to 6 go into more detail in terms of community building, data management, and evaluation and improvement practices respectively. Starting from Stage 3, the design is additionally guided by the Project-Requirements-Catalogue (PRC).

The PRC is one of the major developments of this work. The catalogue extends the process-oriented SSDR with a requirements perspective by grouping the project findings and ordering them according to their dependencies. The catalogue is grouped into four groups namely *Knowledge Base*, *Groundwork*, *Innovations* and *Management*. Each of these groups incorporates one or more of the derived goals of Citizen Science by Minkman (2015) and is oriented around the design pattern of the Seven-layer model of collaboration. The *Knowledge Base* provides an overview of all required and relevant areas of interest, and arranges them in the order of their dependencies. The group *Groundwork* is concerned with the educational, social and political foundation in which the actual project is recommended to be embedded. *Innovations* covers all new developments that need to be made in order to adjust the framework to the local context and *Management* summarizes all other developments and decisions that are required in the previous groups.

The application of this framework resulted in an implementation roadmap for a practical community based participatory mapping and monitoring project in Somaliland. The SSDR together with the PRC could fruitfully guide the application and the practical feasibility together with the SRCS in Somaliland is indicated. The need for better data was confirmed and specified, a possible monitoring routine was developed, feasible AAs were jointly defined with their triggers and technical suggestions for data management were presented. However, the design could only continue until closer consolidation with local stakeholders and communities was required, as this was not feasible within the overall constraints of this work. Nevertheless, a well-ordered knowledge base, structure and conceptual basis for practical implementation could be established.

Chapter 5

Discussion & Reasoning

This study aimed to *first develop a new and transferable framework for community-based participatory mapping and monitoring of water sources for water-scarce and resource-limited settings to facilitate relevant AAs in the context of FbF, and then apply this framework to create an implementation roadmap for the SRCS, ultimately aiming to improve water management and information availability to better address water shortages in Somaliland proactively*. To achieve the first part of this aim, a replicable and adaptable framework was developed based on identified literature and on thematically and methodologically comparable international and local projects. The resulting framework combines a process-oriented SSDR and a requirements-oriented PRC to best guide and structure the design of the respective roadmap for project implementation. The subsequent application of this framework relied primarily on local expert interviews and served to realise the second part of the aim. Here, problems, challenges and early solutions were identified, conceptualised and outlined to create a practical implementation roadmap for a potential realisation in Somaliland.
This chapter critically evaluates and discusses the results of the development and application of the framework. Challenges, implications and constraints that arose during the work and within the findings are explored, outlined and put into context. he chapter is organized into three sections. First, the development of the framework is discussed, followed by its application, and finally the limitations of this work are considered.

5.1 A Replicable & Adaptable Framework

"All models are wrong, but some are useful"

— George E.P. Box

While this statement was made in regard to statistical models, the consideration of the trade-off between generalisation and specialisation is also crucial in the design of frameworks. Highly general principles and characteristics up to highly specialised projects can be found in the literature, see section 2.4. The development of the SSDR has tried to find a balance between the focus on drought, FbF and citizen involvement in Somaliland while also staying adaptable to

other, yet comparable projects.
Surprising was, that while a manifold of general guidelines, characteristics and quality criteria for Citizen Science projects exist, no grouped and ordered requirements list along potential CS goals could be found. While this is unexpected, as it is no radically new insight, but merely a different framing of more or less the same information, it could be explained by the limited time of practitioners to publish concrete information. This lack of time for publication was also mentioned by I2 but no peer-reviewed study could be found to either underline or falsify this assumption. However, an interweaving of the more often encountered process-oriented approach with a specific, yet adaptable requirements catalogue was found to be manageable and, as also later discussed in more detail, well applicable.
In the following, the general development of the SSDR is discussed and the challenges encountered and potential solutions are considered in more detail, looking first at the SSF and then at the PRC. When considering the SSDR and PRC frameworks, it is crucial to acknowledge that they provide only limited perspectives on the complex reality of design processes. This research primarily adopted a process- and requirements-oriented approach in designing and conceptualising the design roadmap. Other perspectives, such as resource, behavioural network or stakeholder networks, cultural norms and values, as well as the communication network perspective may play a role in certain aspects, but are of secondary importance in this work.
Challenges in conceptualising the new framework primarily laid in information availability and transferability. Several CBM, MCS, CBS, CBWM and other risk related CS frameworks and respective guidelines could be identified but none of them exactly matched the intended application, see section 2.4. One possible explanation for this high number of specialized frameworks is, that "there is no one-size-fits-all approach" (Fraisl et al., 2022, p. 2). Therefore, the existing frameworks either focussed on different thematics, contexts, had different participation levels, different goals or a combination of the above, see section 2.4.3. This observation is consistent with Butte et al.'s 2022 and Carrion et al.'s 2020 findings that existing frameworks guiding the development of water security data collection projects are often very specific and limited to certain factors, and in many cases also not taking socio-economic factors into account. At the same time, frameworks like the ones from Butte et al. (2022), CitizenScience.gov (n.d.), and eu-citizen.science (n.d.) and others were too broad, to be more than general guidelines.
This lack of information was also present in a lessened form in relation to Drought FbF. In addition to these case study related domains, there are currently further gaps in knowledge when in comes to the application of the FbF approach on the slow-onset hazard of drought. Generally, the concept of FbF is now well established in regard to fast-onset disasters, but the slow-onset drought use case is relatively new (2020) and not yet well researched, which severely limits the amount of guidelines and frameworks available for this particular application, see section 2.3.1. Thus the FbF approach for drought is still in its infancy itself and while it was to be expected that the literature on Somaliland would be limited, that it would be so severely limited was still somewhat surprisin, see section 2.5. The lack of local and directly related information was overcome by transferring the above information sources through interpolation with

experiences from preliminary work on other, roughly comparable local projects. While such a transfer does not replace direct local knowledge, it can give a first approximation.
Besides the information availability, the novelty and breadth of the CS field led to further challenges which emerged in this work in terms of blurred variables and definitional acuity. While many principles, characteristics and guidelines cover a multitude of design variables, Kirschke et al. (2022) highlight, that the concrete influence and inter-relations of these has not yet been studied in much detail. This leads to a limited understanding of their influences and impacts for success. This lack of understanding also became apparent in this work and prevented more accurate attribution in the design phase. Though, this might not be as relevant any more once the project is implemented and more local knowledge and understanding is gained, as this work aims to implement rather than scientifically evaluate the individual variables.
Most of the guidance identified in the literature analysis and later also integrated suggest primarily positive constraints, see sections 2.4 and 4.1. The assessment guidelines of the IFRC (2017) were the only identified guideline formulating concrete *red flags*. This was unexpected, as negative constraints can clearly enhance the formulation of conceptual and practical boundaries. These *red flags* were included in the assessment in Stage 2, as they represent a stronger barrier than positive constraints and thus support a more careful assessment. However, ESCA et al. (2020) argues, that because of the various fields of application, disciplinaries and cultural contexts, defining a "universal set of rules for exclusion or inclusion is difficult, and might even limit the advancement of the field" (p.1). Besides the integration of the *red flags*, this was taken into account by keeping the SSF relatively general and mainly implementing more precise requirements for the applied case in the PRC.

In the following, major design decision for the SSDR are shortly outlined and reasoned. The decision to build on Fraisl et al.'s 2022 Six-Stage-Framework was primarily driven by its timeliness, comprehensiveness and focus on environmental issues as it was clear, that a more social and local component can be integrated from the SRCS's experiences with CBS. The results indicate, that the interpolation of these two approaches was useful, especially in consideration of personal data. While observing natural phenomena at the level of data collection did not raise too many privacy concerns for Fraisl et al. (2022), this was almost the opposite for CBS (IFRC, 2017). Applying these contrasting perspectives to the issue of water sources was thus able to address both the physical and social components well by considering trade-offs between the two 'extremes'. This observation was further supported over the course of this work, when the iterative integration of other guidelines from several divergent foci into the existing framework could be implemented smoothly and only minor revisions had to be made. This goes along McGowan et al. (2022) findings, that the success factors of CBS are closely linked to the general principles of participatory community engagement and may therefore be transferred to other participatory surveillance preparedness activities.
In the application of the SSF as basis for this design and implementation roadmap creation, some major adjustments were made. The main overall adaptation were the shortening of the iteration cycle by the first two stages. It became clear, that the exploration and assessment stages do not need to be regularly integrated in the iterative design once the third stage is

reached, see figure 4.1. Nonetheless, when new fundamental findings or discoveries are made, it may be necessary to partly go back to Stage 1. The same also applies to Stage 2, when one of the defined *red flags* is violated in the further course of the work. Further adaptation were made in the integration of the feasibility assessment and *red flags* of the IFRC in Stage 2, the integration of the PRC and IWRM framework in Stage 3 and the focus on iterative improvements in Stage 6. However, the applicability of these changes could only be tested in the conceptual stage and not evaluated in practice due to time and resource constraints. Nevertheless, applicability can be assumed to be likely, as all adjustments were based on experiences and studies of already conducted or peer-reviewed work and integrated well with the overall framework, see section 4.1. Furthermore, the locally experienced interviewees all agreed on the feasibility in the context of Somaliland.

The reasons, specifics and their implications of the Project-Requirements-Catalogue are discussed in this final part, of the section which addresses the first research question. The development and integration of the PRC attempted to address some of the shortcomings of the process-oriented SSDR. These shortcomings became apparent right at the beginning of the application in the third stage. It was increasingly difficult to keep an overview of the actual project requirements and their interdependencies in terms of subject matter and temporal constraints, see section 4.2.1. Furthermore, CBS, CBWM and other approaches have strongly emphasised the importance of embedding the project into prevailing social and decision-making conditions and procedures, which became apparent to be under-represented in the SSF, see section 4.2.2. The results of the CBS analysis also highlighted the high time and resource requirements, which were needed for the development and adaptation of methods and techniques to start with the CBS project in Somaliland. This goes along with García et al.'s 2021 findings, that some adjustments and tailoring always need to be done when implementing a new project, see section 4.2.3. Together with the emerging need to structure smaller developments and create an overview of decision dependencies, a fourth area of management became apparent that needed to be addressed, see section 4.2.4.

The emphasis of the top most layers, the *Goal-, Products-, and Activities-Layer* (see section 3.2.2) is reasoned by overall time and resource constraints along with the realisation that the latter four layers *Methods, Techniques, Tools and Scripts* are too detailed for a relatively general framework. However, it needs to be acknowledged, that the thematic focus of the SLMC is not on CS and that the goals derived by (Minkman, 2015) were primarily focussed on being potential goals of the project itself, and not meant to guide the conceptual phase. Nonetheless, the overall design pattern of the SLMC together with the formulated goals could support the conceptualisation considerably. The close integration of Minkman's 2015 goals in this conceptual way may also bring about their 'automatic' consideration during the design, which might lead to a greater breadth of output.

The PRC structure is closer related to the case study area as the SSF but should still be adaptable to other contexts as the high level products mostly relate to general parts of the project and not to concrete techniques or tools. However, the PRC should not be separated from the SSDR as many products are addressed by activities mentioned in this framework, which are not specifically mentioned again in the PRC. Its final applicability can only be evaluated in practices but generally, formulating project requirements in detail is nothing new and should also benefit a CS project approach (Wiegers & Beatty, 2013; Young, 2001, 2006). Due to the generally iterative nature of this framework, both classical and agile development practices can be applied, with the latter possibly having the advantage (Conforto et al., 2014; "Manifesto for Agile Software Development", n.d.).

Besides the above mentioned challenges in the design phase and the general limitations named in the last section of this chapter, the work will also encounter challenges in the implementation and operation phases. In the (practical) application of this framework, some adjustments will be necessary and as it was the case of this work, time and resource constraints will be imposed by overarching projects or conditions, making some compromises inevitable. This is discussed in the next section in the case of creating a roadmap for implementation in Somaliland.

5.2 Application in Somaliland

This section discusses the conducted application of the SSDR and PRC for the creation of an implementation roadmap in the case study area. It is structured according to the six stages. Unexpected findings in this application were the issue about the server location in Ireland, the competition between the NGOs, and the MoH's initially negative attitude towards the inclusion of CBS due to oversupply by international NGOs. Furthermore, the heterogeneity in the community and stakeholders potentially contrary attitudes to the projects as highlighted by the interviewees in regard to the implementation was also only rarely mentioned in the considered guidelines. Specifically, results indicate, that local stakeholders such as private berkad owners or private water vendors may not only be in favour of this project. To be aware of financial motivations of all parties was only mentioned by Minkman (2015) in the context of the literature considered in this thesis. However, this work was not a literature review about motivational factors of stakeholders, therefore, this can only be regarded as an unexpected first impression and does not imply more.

The exploration Stage 1 allowed for an open search in all directions and supported the identification and specification of the problem, context, project boundaries and to formulate first draft solutions. The situation on the ground was identified as severe and complex, with many interrelated and partly specific conditions and indicated, that the combination of topics is new and under-researched. Supported by these findings, the research type case study, in combination with the iterative mixed-method approach of literature and project analysis along expert interviews can in retrospective reasonably be assumed as fit for purpose. Further discussion of the methods is addressed in the coming section about limitations.

The topic of community-based participatory water monitoring was found to be closely related to the already established CBS project, which supported the transfer of knowledge to this new project. However, water source data set explorations could not support a further analysis due to the identified poor quality and incompleteness. This finding corresponds well with the impressions of the higher-level EAP development team and (Harrowsmith et al., 2020). Another identified challenge was the current allocation mechanisms and risk assessment in regard to water trucking. However, this was not the aim of this work and will be addressed by the EAP.

The conducted feasibility assessment suggests the applicability of the project in the context of Somaliland. However, not all *red flags* could be addressed due to this works constraints. In particular, one *red flag* in regard to information sharing about exact water source locations may need more thought and consultations in the light of the relatively recent history of Somaliland where information about this critical infrastructure was used against the general public (Republic of Somalia, 2021). Findings also suggest the importance of an additional technical support as the capacities of SRCS are particularly limited in this regard.

In stage 3, the subdivision into the PRC was helpful to reduce cognitive overload and highlight chronological and thematic (inter-) dependencies. In terms of knowledge, the PRC helped to structure the information identified in Stages 1 and 2, which additionally helped to make knowledge gaps, such as lack of detailed knowledge about local decision-making procedures, more visible. As it is was not feasible to gather these information in the scope of this work, it was therefore simplified to concentrate on those areas, that could be addressed. For example, it became clear that the initial mapping, which also includes the gathering of other key information about the berkad, cannot be done by local volunteers as the knowledge and technical equipment requirements are too high for most. Thus the initial mapping needs to be conducted by SRCS professionals who already meet the requirements. Nonetheless, gathering the information that is initially required for the mapping campaign was feasible in the context of this work and was therefore focussed on. The knowledge gathered was thus more broad than deep and in most cases requires further investigation, especially in relation to local conditions. Furthermore, to realise the full potential of the framework in a possible practical application, the findings from this textual version should be mapped and described in a conceptually clear way to products and activities This was attempted and presented in the case of general AA requirements (see figure 4.8 and more specifically in the case of the AA of water trucking, see figure 4.9 in section 4.3.3. Here, requirements could be listed in a structured way, but their further specification is only possible on the ground with local stakeholders.

The findings suggest, that a sound foundation for general groundwork for this project is already laid (see section 4.3.3) as volunteers are well embedded in the social network and communities already manage water regulations themselves. Furthermore, the already conducted health related AAs of awareness raising about water borne diseases and water tablet dissemination suggests the assumption, that general familiarity with the topic of water management also already exists. Therefore, while the integration of an entire IWRM may be a project on its own, at least aspects of this can potentially be well and easily integrated within the already prevailing procedures. However, contrary opinions must not be disregarded here either. The synthesis of knowledge will need to be discussed with local community leaders and key stakeholders and will strongly depend on the local context. Nonetheless, findings indicated willingness and experience of local managers to implement those concepts, which suggests at least a good initial situation for the successful embedding of the project into local management practices.

Besides the conceptual groundwork directly on site, innovations for the determination and collection of water level thresholds are required. The gathered information suggest, that there are two potential ways to assess the water level, see section 4.3.3. The more technical measuring and transmission of the actual water height would require knowledge about the exact capacity and size of the berkad to assess the remaining water capacity. Although this method would provide a more objective measurement, local knowledge of the potential duration of water supply was also found to be good, see section 4.3.3. Both approaches do not contradict each other and could also be used together. This would also allow a good basis over time for evaluating the quality of the assessment of local knowledge what could then improve local water monitoring methods and management. Potential codes were developed, but need to be evaluated in practice. In addition to the quantity of water, its quality was also considered very important, but no locally feasible approach to assessing quality could be identified. This supports the importance of providing a sound knowledge foundation about contamination prevention and water management practices to the community. This is also supported by several other studies (Daniel et al., 2020; Huang et al., 2020; Tariq et al., 2021; WMO, 2013). Furthermore, this topic of water quality can certainly be further linked with the already ongoing CBS project to generate further synergies. While no management decision or developments could be made or evaluated in practice in the scope of this work, the findings suggest some additional considerations. Gualazzini (2021) highlighted that local actors may be aware that their answers can influence the subsequently provided help but also mentioned, that this can be addressed by good supervision structures and preliminary training. This is also supported by experiences from the CBS approach which also suggest that these measures can greatly mitigate reporting biases.

In the case of deciding for a specific water source monitoring strategy, all accessible water sources in a community should be monitored. The gathered information suggests, that the largest source, e.g. a ballay, is not necessarily the water source that can withstand a period of drought the longest. Physical as well as social access factors need to be considered in terms of actual water withdrawal and monitoring when deciding on the actual monitoring routine, see section 4.3.3.

It can be acknowledge that the water level of berkads is not the end of a potential monitoring routine. United Nations Children's Fund (UNICEF) and World Health and World Health Organization (2018) created an extensive questionnaire for their interview surveys and Enenkel et al. (2020) formulated questions that are relatively simple and remotely monitorable and give a bigger picture of the situation by aligning socio-economic elements with weather and climate monitoring. Their work may give additional insights for the extension of this approach. Though, the results of this work suggest, that the integration of even some of these questions may already go far beyond the scope of this project. Nevertheless, certain aspects can provide suggestions for practically implementable adjustments, e.g. the simple integration of precipitation measurements, which could already significantly improve the data situation. Possibly, a correlation could also be made with other measurements to see if the water level can also serve as a proxy for other parameters.

The findings support the feasibility and usefulness of a staggered trigger as proposed by RCRC (2020) for triggering on water level thresholds as both, a seasonal and a short-term assessment are possible. In terms of AAs, the results supported the feasibility of water trucking and cash transfer AAs (see sections 2.5.5 and 4.3.3), which compares well with Gettliffe's 2021 findings. Yet, when comparing this finding with the statements of the interviewees from section 4.3.1 that water is often over prized in times of scarcity and with the statement of OCHA (2020) that markets need to be operational to permit the adequate and reasonable handling of the demand, distributions of cash or water vouchers may not always be feasible as AAs. These findings compare well with similar EAPs in Lesotho and Niger. Direct cash or voucher distributions are also part of these EAP's AAs and the EAP in Niger also accounts for higher market prices inits food security measures by including subsidies for cereal prizes.

The community building aspect in Stage 4 was primarily focussed on assessing the capacities of the SRCS. The findings suggest good capacities and high experiences in the area of community engagement as well as volunteer training and supervision, see sections 4.3.4 and 4.3.2. This was to be expected, as the SRCS already successfully implemented a comparable project and is also found to be performing well within the framework of the overarching FbF project. Community selection of volunteers, which reinforces altruistic and communal values for lasting participation, is also indicated in the study by (Rotman et al., 2012). Unexpected was the finding that volunteers are primarily women, as this contrasts with the trend in CS participation generally found in the literature (Ibrahim et al., 2021; Pateman et al., 2021).

Findings of Stage 5 *Data management* support the technical practicability of the project. The solution of the implemented CBS project with the NYSS platform is identified to be very dedicated and an adaptation is technically possible to the new requirements. Currently, discussions about the adaptation are ongoing on management level. However, the results also suggest that this project can be carried out using less specialised approaches than the NYSS platform presented, which could potentially simplify the technical aspects, see sections 4.3.5 and 2.4.2.
A major concern of data collected by CS is their quality and accuracy. The findings indicate that these are well addressed in the current CBS by the initial and refresher trainings of the participants, close supervision and further verifications when necessary. Further data triangulation with third party information may also improve confidence in the data. These QC and QA measures and the relatively simple task of water level monitoring are also identified in current literature as adequate CS applications with good results (Albus et al., 2020; Baalbaki et al., 2019; Fraisl et al., 2022). Furthermore, (Aceves-Bueno et al., 2015) findings suggest, that usefulness of the data may also be given, even though data quality issues persist to some extent. However, the greater constraint than quality in this case might be the limited number of total codes per message. Here, the results indicate that no more than three codes for weekly monitoring are

reasonably feasible without making major compromises in the choice of volunteers. Nevertheless, the CBS project has already achieved some success with this restriction.
Using more dedicated sensors such as smartphones, sensors or remote imagery are solutions considered in other projects, but the findings indicate that the rural population rarely has smartphones, sensors usually need some kind of network which may not be given, and berkads are often roofed and too small for satellite imagery (Bartram et al., 2014; Klemas & Pieterse, 2015; Mao et al., 2020; Masinde & Thothela, 2019; McNeil et al., 2022; Senay et al., 2013; Thomson, 2021). The problem of network coverage is circumvented in this project as the volunteer is mobile and can go to a place with network reception, making the SMS coding solution the only viable solution at present.

Evaluation practices are integrated in every stage but due to no actual implementation and operation, evaluation could not be conducted. Nonetheless, the design process, due to its iterative processes underwent several evaluations and piecemeal improvements itself suggesting good adaptability and upgradeability. One big open question that remains for the overarching EAP is the definition of success metrics for evaluation, which can significantly influence further developments.

The overall application of the developed framework worked well and the combination of the SSF together with the PRC based on the SLMC could provide good guidance while also remaining flexible to incorporate new and unexpected findings. Yet, the entire power of the SLMC could not be exploited as the coming layers were too detailed and most of those need to be determined in closer collaboration with the EAP team and the local stakeholders. Nonetheless, based on the positive experiences with the first three stages, it can reasonably be assumed that the following layers will also prove fruitful to potential future developments.

The application also supports the findings of García et al. (2021) and C. T. Conrad and Daoust (2008) that a framework should be used in designing a CS project but also highlights the need to adapt this framework to the actual projects conditions and goals. Furthermore, the work suggests that a respective implementation of a Citizen Science project is not only theoretically feasible but practically implementable. While an end to end establishment of an implementation roadmap was not feasible in the context of this work due to given limitations, it can reasonably be assumed, that a sound foundation could be laid for further practical implementation in the scope of a pilot study. Yet, important questions need to be answered on management level and not all indicators are in favour of a practical application. For example, the RCRC is generally not recommending its National Societies to implement their own data gathering strategies as this would, under normal circumstances, over-burden and exceed costs (RCRC, 2020). Therefore, RCRC (2020) generally recommends to found the triggers and information on already gathered information by other stakeholders or international organisations. However, as suggested by the results, this is not feasible in this context. Furthermore, the analysis of the CBS approach and other projects together with the feasibility assessment and conducted application of this work suggest that CS can be a reasonable and cost-effective approach to gather relevant information for triggering AAs. This is also supported by Aceves-Bueno et al. (2015) and Minkman (2015) findings. Finally, the results allow for the assumption that this timely

and accurate data will be able to support appropriate Anticipatory Actions, potentially making mitigation and responses more streamlined, efficient and effective.
Besides the high demands and complexity of the CS project design itself, this process also highlighted, that CS is not a silver bullet itself but comes with various advantages and disadvantages. While the final application may seem appealing, as a lot of the work is done by the contributing citizens, particularly the design and implementation poses a lot of requirements in time, skill, and resources. This complexity is also mentioned by Fraisl et al. (2022) and Minkman (2015) highlighting the statement, that Citizen Science is one of many methods and its deployment should be well considered.

5.3 Study's Limitations

In any research project, limitations are an important aspect to consider and some were already addressed in the above discussion. Yet, there are further limitations that need to be acknowledged. The literature review did not follow a strict formal structure and that comparable projects may have been overlooked, although unlikely, cannot be ruled out. Nonetheless, this exploratory approach also allowed for the discovery of many, formerly unknown aspects and contributed many insights to the study. The subsequent in depth literature analysis, although not formal, was detailed, extended and was able to identify and address some gaps. However, the generally sparse literature on Somaliland limited the desk-based collection of information about local conditions. Furthermore, this work has also not addressed the integration or application of local and/or indigenous knowledge or the further use of VGI, to the extent that this would have been possible in principle. Although both areas are very interesting, this was either not the focus of this work or, in the case of available water source datasets and VGI, in-depth analysis was deemed inappropriate due to the poor quality identified early on. Nevertheless, insights could be gained from the data using more refined methods in future work. On the theoretical level of the contextual basis, the concepts mentioned, such as water security, drought or Citizen Science, are extremely complex and highly debated topics. Discussing them in detail would have exceeded the scope of this thesis, which is why focal points were set according to the priority of this work.

The inclusive nature of the exploratory approach, was thus tried to be addressed by information triangulation from other studies but it made for a generally more consensual work and fewer contradictory findings. This, together with the inclusion of most relatable studies and projects into the framework itself, also made for a relatively homogeneous discussion due to the lack of contradictory findings. It is expected that this comparison with other work will be possible in the future as more CS projects are carried out in a similar context and with similar objectives.

The critique of the case study research type, its challenge to execute, significant documentation efforts and complex nature also had certain shares in this work. Nevertheless, its strength of being rich, detailed and contextual also contributed positively. The generalisability of the understanding gained through actual application can be considered low, but the applicability of the framework developed can be expected to be transferable to other comparable contexts. An attempt was made to improve internal validity through the iterative design, reciprocal reviews and triangulation of multiple sources of information, but despite great efforts, it is hardly possible to establish causal relationships in such a complex environment in just one case study. Constructed validity of the framework is believed to be reasonable due the extensive triangulation of resources but can only be evaluated in a practical examination. The importance of data triangulation was also noted and integrated in the actual application. Interviews always add a human factor which can complicate repeatability but clear procedures and documentation were established to account for this as best as possible. The expert and snowball sampling strategy itself worked well, but was severely limited by other factors. The interviews always had to be arranged and signed off by senior managers, and the already tense situation with ongoing response activities and parallel FbF development in Somaliland made the availability of interviewees even scarcer. This resulted in a relatively low sample of interviewees, limiting the otherwise strength of a case study to incorporate a multitude of perspectives on one area of interest. Here, interviews especially with representatives of NADFOR, the MoWR and MoH as well as BRCiS and OCHA might have been fruitful. The conversion of one interview into a questionnaire hindered direct clarification and follow-up questions in the interview, but this could be compensated for by a second questionnaire. Since a lot of information could be drawn from the answers and the interview could not have taken place otherwise, this can ultimately be seen as a good compromise.

Overall, the study was conducted under difficult conditions in a case study area known for its complex and difficult environment. The generally limited time and resources available in the context of a Master's thesis further constrained the study and the focus on just the development of the framework might have been beneficial. Nevertheless, it is believed that the study conducted was ultimately able to provide a good theoretical and structural basis for a potential practical implementation of this approach. Furthermore, this study contributes to the general ongoing discourse of Citizen Science-projects by adding a work from a currently under-represented region. It is to be expected that in the further process of this discourse many of the limitations mentioned here can be addressed and overcome.

Chapter 6

Conclusion & Outlook

This chapter concludes the study by summarising the main research findings in relation to the research questions and aim. It highlights the value of its contributions and suggests possibilities for future research.
This study has investigated the intersection of Forecast based Financing (FbF) policies and techniques, Citizen Science (CS) approaches and methods, and water management structures and procedures in Somaliland. This investigation was driven by the aim to *first develop a new and transferable framework for community-based participatory mapping and monitoring of water sources for water-scarce and resource-limited settings to facilitate relevant Anticipatory Actions in the context of FbF and then apply this framework to create an implementation roadmap for the SRCS, ultimately aiming to improve water management and information availability to better address water shortages in Somaliland proactively.*
Guided by two research questions on what such a framework could look like and how it could subsequently be applied in Somaliland, a mixed-methods approach combining literature analysis and expert consultations was applied to develop a tailor-made framework and create an implementation roadmap. The results indicate that integrating the concepts of FbF and CS for monitoring water source levels in resource-scarce settings to ultimately trigger Anticipatory Actions into one framework is theoretically possible and may add a local socio-economic perspective to the otherwise physically focused insights. In the case of Somaliland, the practical feasibility of this integrated framework can also be reasonably assumed based on the literature and especially the expert interviews.

This work further diversified the literature on Citizen Science projects by contributing a case study in regions other than North America and Europe. The development of the adaptable and replicable Six-Stage-Design-Roadmap and Project-Requirements-Catalogue framework may allow other work with similar aims and conditions to have a closer start of reference for designing their own project. Specifically in this context, the thesis laid a starting point for the implementation of a practical pilot study by the Somalia Red Crescent Society. This may lead to better data on water sources, which in turn could contribute to the implementation of Anticipatory Actions to ultimately better address water shortages.

This study was primarily constrained by a modest number of interviewees, no opportunity for on site work and general time constraints. Therefore, the work remained at the conceptual stage and could not be evaluated against a practical application. Other evaluation options, such as direct comparison with other similar projects, were not feasible due to the novelty of the project and the consequent lack of similar ones. In addition, no concrete technical approaches and possibilities for data triangulation could be formulated as decisions at management level had not yet been finalised.

Future research can directly continue where this work left of by implementing an on site pilot study, continue to dig deeper into one of the many questions that have arisen or focus on overcoming the current limitations. A pilot study could potentially address most of the primary constraints of this work and continue to adapt, implement and evaluate it locally. There are several questions worth asking in such a case study. Apparent areas of interest are the investigation of the water level measurement method, corresponding codes, and the assessment of triggers and Anticipatory Actions. In terms of community engagement, exploring ways of integrating Integrated Water Resource Management with prevailing local practices on an equal footing, asking what the involvement of community elders might look like, and addressing issues of community heterogeneity and gender inequalities may all be potentially fruitful enquiries. Also of great interest is what benefits a two-way communication with the participants could further yield, particularly in terms of receiving and integrating local and indigenous knowledge and providing weather and climate predictions and warnings. Furthermore, investigations and evaluations in various other fields will be required when further exploring a practical implementation.
The limitations of low external and internal validity and the question of whether the framework can be applied to other contexts may be addressed by further case studies in similar contexts and by including other methods such as upscaled surveys. The further investigation of the link between the water level proxy, vulnerability and impact may add further value to the argument of constructed validity. In addition, inter-project comparisons as well as comparisons with other methods, e.g. (remote-)sensor networks could be investigated. Besides these application-related questions, it would be interesting to examine more closely the recognised positivity bias and its effects in CS guidelines and frameworks.

Bibliography

Abdulkadir, G. (2017). Assessment of Drought Recurrence in Somaliland: Causes, Impacts and Mitigations. *Journal of Climatology & Weather Forecasting*, *05*(02). https://doi.org/10.4172/2332-2594.1000204

Aceves-Bueno, E., Adeleye, A. S., Bradley, D., Tyler Brandt, W., Callery, P., Feraud, M., Garner, K. L., Gentry, R., Huang, Y., McCullough, I., Pearlman, I., Sutherland, S. A., Wilkinson, W., Yang, Y., Zink, T., Anderson, S. E., & Tague, C. (2015). Citizen Science as an Approach for Overcoming Insufficient Monitoring and Inadequate Stakeholder Buy-in in Adaptive Management: Criteria and Evidence. *Ecosystems*, *18*(3), 493–506. https://doi.org/10.1007/s10021-015-9842-4

Akanbi, A., & Masinde, M. (2018, August 7). *Towards the Development of a Rule-Based Drought Early Warning Expert Systems Using Indigenous Knowledge*. https://doi.org/10.1109/ICABCD.2018.8465465

Albus, K. H., Thompson, R., Mitchell, F., Kennedy, J., & Ponette-González, A. G. (2020). Accuracy of long-term volunteer water monitoring data: A multiscale analysis from a statewide citizen science program. *PLOS ONE*, *15*(1), e0227540. https://doi.org/10.1371/journal.pone.0227540

Alfonso, L., & Jonoski, A. (2012, July 14). *Mobile phone applications for water management: Classification, opportunities and challenges.*

Ali, N. M., & Jemal, K. (2017). Mitigating Natural Disasters in Somaliland Policy Options and Strategies, 8.

Allen, K. (2018). *Community-Based Water Monitoring and Decision Making*. Environmental Law Centre, University of Victoria.

Anderson, W. B., Han, E., Baethgen, W., Goddard, L., Muñoz, A. G., & Robertson, A. W. (2022). The Madden-Julian Oscillation affects crop yields around the world. *Authorea Preprints*.

Andersson, L., Wilk, J., Graham, L. P., Wikner, J., Mokwatlo, S., & Petja, B. (2020). Local early warning systems for drought – Could they add value to nationally disseminated seasonal climate forecasts? *Weather and Climate Extremes*, *28*, 100241. https://doi.org/10.1016/j.wace.2019.100241

Arreguin-Cortes, F. I., Saavedra-Horita, J. R., Rodriguez-Varela, J. M., Tzatchkov, V. G., Cortez-Mejia, P. E., Llaguno-Guilberto, O. J., Sainos-Candelario, A., Sandoval-Yoval, L., Ortega-Gaucin, D., Mendoza-Cazares, E. Y., & Navarro-Barraza, S. (2019). Municipal level water security indices in Mexico. *SN Applied Sciences*, *1*(10), 1194. https://doi.org/10.1007/s42452-019-1180-2

Asiimwe, C., Gelvin, D., Lee, E., Amor, Y. B., Quinto, E., Katureebe, C., Sundaram, L., Bell, D., & Berg, M. (2011). Use of an Innovative, Affordable, and Open-Source Short Message Service–Based Tool to Monitor Malaria in Remote Areas of Uganda. *The American Journal of Tropical Medicine and Hygiene*, *85*(1), 26–33. https://doi.org/10.4269/ajtmh.2011.10-0528

Baalbaki, R., Ahmad, S. H., Kays, W., Talhouk, S. N., Saliba, N. A., & Al-Hindi, M. (2019). Citizen science in Lebanon—a case study for groundwater quality monitoring. *Royal Society Open Science*, *6*(2), 181871. https://doi.org/10.1098/rsos.181871

Balint, Z., Mutua, F., Muchiri, P., & Omuto, C. T. (2013). Monitoring Drought with the Combined Drought Index in Kenya. In *Developments in Earth Surface Processes* (pp. 341–356, Vol. 16). Elsevier. https://doi.org/10.1016/B978-0-444-59559-1.00023-2

Balti, H., Abbes, A., Mellouli, N., Farah, I., Sang, Y., & Lamolle, M. (2020). A review of drought monitoring with big data: Issues, methods, challenges and research directions. *Ecological Informatics*, *60*, 101136. https://doi.org/10.1016/j.ecoinf.2020.101136

Baptiste, S., Manouan, A., Garcia, P., Etya'ale, H., Swan, T., & Jallow, W. (2020). Community-Led Monitoring: When Community Data Drives Implementation Strategies. *Current HIV/AIDS Reports*, *17*(5), 415–421. https://doi.org/10.1007/s11904-020-00521-2

Bartram, J. (2009). *Water safety plan manual: Step-by-step risk management for drinking-water suppliers*. World Health Organization.

Bartram, J., Brocklehurst, C., Fisher, M. B., Luyendijk, R., Hossain, R., Wardlaw, T., & Gordon, B. (2014). Global Monitoring of Water Supply and Sanitation: History, Methods and Future Challenges. *International Journal of Environmental Research and Public Health*, *11*(8), 8137–8165. https://doi.org/10.3390/ijerph110808137

Baudoin, M.-A., Henly-Shepard, S., Fernando, N., & Sitati, A. (2014). Early warning systems and livelihood resilience: Exploring opportunities for community participation. Retrieved October 26, 2022, from https://collections.unu.edu/view/UNU:3174#viewMetadata

BBC. (2022). Somaliland profile [newspaper]. *BBC News: Africa*. Retrieved March 21, 2023, from https://www.bbc.com/news/world-africa-14115069

Bennett, J. (2010, September 22). *OpenStreetMap*. Packt Publishing Ltd.

Birch, I. (2008). Somaliland/Somali Region Desk Review.

Blauvelt, R. (2014). Systematizing Environmental Indicators and Indices. *Journal of Environment and Ecology*, *5*, 15. https://doi.org/10.5296/jee.v5i1.4864

Boetzelaer, E. V., Chowdhury, S., Etsay, B., Faruque, A., Lenglet, A., Kuehne, A., Carrion-Martin, I., Keating, P., Dada, M., Vyncke, J., Kazungu, D. S., & Verdecchia, M. (2020). Evaluation of community based surveillance in the Rohingya refugee camps in Cox's Bazar, Bangladesh, 2019. *PLOS ONE*, *15*(12), e0244214. https://doi.org/10.1371/journal.pone.0244214

Botai, O., Botai, C., Wit, J., Masinde, M., & Abiodun, A. (2019). Analysis of Drought Progression Physiognomies in South Africa. *Water*, *11*, 299. https://doi.org/10.3390/w11020299

Boult, V. L., Black, E., Saado Abdillahi, H., Bailey, M., Harris, C., Kilavi, M., Kniveton, D., MacLeod, D., Mwangi, E., Otieno, G., Rees, E., Rowhani, P., Taylor, O., & Todd, M. C. (2022). Towards drought impact-based forecasting in a multi-hazard context. *Climate Risk Management*, *35*, 100402. https://doi.org/10.1016/j.crm.2022.100402

Brabham, D. C. (2008). Crowdsourcing as a Model for Problem Solving: An Introduction and Cases. *Convergence*, *14*(1), 75–90. https://doi.org/10.1177/1354856507084420

Briggs, R. O., Kolfschoten, G., de Vreede, G.-J., Albrecht, C., & Dean, D. R. (2009). A Seven-Layer Model of Collaboration: Separation of Concerns for Designers of Collaboration Systems, 16.

Buckingham Shum, S., Aberer, S., Schmidt, K., Jelasity, M., Karpištšenko, M., Kohlhammer, A., Lewis, J., Pitt, J., Sumner, J., Buckingham Shum, S., Aberer, K., Schmidt, A., Bishop, S., Lukowicz, P., Anderson, S., Charalabidis, Y., Domingue, J., Freitas, S., Dunwell, I., & Helbing, D. (2012). Towards a global participatory platform: Democratising open data, complexity science and collective intelligence. *The European Physical Journal Special Topics*, *214*, 109–152. https://doi.org/10.1140/epjst/e2012-01690-3

Budde, M., Schankin, A., Hoffmann, J., Danz, M., Riedel, T., & Beigl, M. (2017). Participatory Sensing or Participatory Nonsense? Mitigating the Effect of Human Error on Data Quality in Citizen Science. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *1*(3), 39:1–39:23. https://doi.org/10.1145/3131900

Butte, G., Solano-Correa, Y. T., Peppa, M. V., Ruíz-Ordóñez, D. M., Maysels, R., Tuqan, N., Polaine, X., Montoya-Pachongo, C., Walsh, C., & Curtis, T. (2022). A Framework for Water Security Data Gathering Strategies. *Water*, *14*(18), 2907. https://doi.org/10.3390/w14182907

Butterworth, J., Warner, J. F., Moriarty, P., Smits, S., & Batchelor, C. (2010). Finding practical approaches to integrated water resources management. *Water alternatives*, *3*(1), 68–81.

Byrne, A., & Nichol, B. (2020). A community-centred approach to global health security: Implementation experience of community-based surveillance (CBS) for epidemic preparedness. *Global Security: Health, Science and Policy*, *5*(1), 71–84. https://doi.org/10.1080/23779497.2020.1819854

Cabot Venton, C. (2018). Economics of resilience to drought in Ethiopia, Kenya and Somalia. *USAID, Washington DC. Available from www. usaid. gov*.

Canada, L. L. (2018). Community-Based Water Monitoring National Survey Highlights, February 2018.

Canada, L. L., Foundation, T. G., & WWF-Canada. (2018). *Elevating Community Based Water Monitoring – Featured Case Study*. https://livinglakescanada.ca/wp-content/uploads/2019/04/Case-Studies-Final-Spreads.pdf

Capponi, A., Fiandrino, C., Kantarci, B., Foschini, L., Kliazovich, D., & Bouvry, P. (2019). A Survey on Mobile Crowdsensing Systems: Challenges, Solutions, and Opportunities. *IEEE Communications Surveys & Tutorials*, *21*(3), 2419–2465. https://doi.org/10.1109/COMST.2019.2914030

Caretta, M., Mukherji, A., Arfanuzzaman, M., Betts, R., Gelfan, A., Hirabayashi, Y., Lissner, T., Liu, J., Lopez Gunn, E., Morgan, R., Mwanga, S., & Supratid, S. (2022). Water. In H.-O. Pörtner, D. Roberts, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change* (pp. 551–712). Cambridge University Press. https://doi.org/10.1017/9781009325844.006

Carrion, D., Pessina, E., Biraghi, C. A., & Bratic, G. (2020). Crowdsourcing water quality with the SIMILE app. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLIII-B4-2020*, 245–251. https://doi.org/10.5194/isprs-archives-XLIII-B4-2020-245-2020

Cassivi, A., Guilherme, S., Bain, R., Tilley, E., Waygood, E. O. D., & Dorea, C. (2019). Drinking water accessibility and quantity in low and middle-income countries: A systematic review. *International Journal of Hygiene and Environmental Health*, *222*(7), 1011–1020. https://doi.org/10.1016/j.ijheh.2019.06.011

Cassivi, A., Tilley, E., Waygood, E. O. D., & Dorea, C. (2021). Evaluating self-reported measures and alternatives to monitor access to drinking water: A case study in Malawi. *Science of The Total Environment*, *750*, 141516. https://doi.org/10.1016/j.scitotenv.2020.141516

CDC. (2022a, March 24). *Assessing Access to Water & Sanitation*. Centers for Disease Control and Prevention. Retrieved March 8, 2023, from https://www.cdc.gov/healthywater/global/assessing.html

CDC. (2022b, November 8). *One Health Basics*. Retrieved March 18, 2023, from https://www.cdc.gov/onehealth/basics/index.html

Cervoni, L., Biro, A., & Beazley, K. (2008). Implementing integrated water resources management: The importance of cross-scale considerations and local conditions in Ontario and Nova Scotia. *Canadian Water Resources Journal*, *33*(4), 333–350.

CitizenScience.gov. (n.d.). *Basic Steps for Your Project Planning*. Retrieved February 3, 2023, from https://www.citizenscience.gov/toolkit/howto/

CoCoRaHS. (2023). *CoCoRaHS - Community Collaborative Rain, Hail & Snow Network*. Retrieved September 28, 2022, from https://www.cocorahs.org/

Commission, E. (2021). *A citizen-centred approach to smart cities | Research and Innovation*. Retrieved March 18, 2023, from https://ec.europa.eu/research-and-innovation/en/projects/success-stories/all/citizen-centred-approach-smart-cities

Conforto, E. C., Salum, F., Amaral, D. C., da Silva, S. L., & de Almeida, L. F. M. (2014). Can Agile Project Management be Adopted by Industries Other than Software Development? *Project Management Journal*, *45*(3), 21–34. https://doi.org/10.1002/pmj.21410

Conrad, C. (2007). Community-based monitoring and the science of water quality. *IAHS Publ.*, *314*.

Conrad, C. (2006). Towards Meaningful Community-Based Ecological Monitoring in Nova Scotia: Where are we versus where we would like to be. *Environments*, *34*(1), 25.

Conrad, C. T., & Daoust, T. (2008). Community-Based Monitoring Frameworks: Increasing the Effectiveness of Environmental Stewardship. *Environmental Management*, *41*(3), 358–366. https://doi.org/10.1007/s00267-007-9042-x

Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: Issues and opportunities. *Environmental Monitoring and Assessment*, *176*(1), 273–291. https://doi.org/10.1007/s10661-010-1582-5

contributors, O. (n.d.). *OpenStreetMap*. OpenStreetMap. Retrieved March 18, 2023, from https://www.openstreetmap.org/

Coughlan de Perez, E., van den Hurk, B. J. J. M., Van Aalst, M. K., Jongman, B., Klose, T., & Suarez, P. (2015). Forecast-based financing: An approach for catalyzing humanitarian action based on extreme weather and climate forecasts. *Natural Hazards and Earth System Sciences*, *15*(4), 895–904.

Coughlan de Perez, E., van den Hurk, B., van Aalst, M. K., Amuron, I., Bamanya, D., Hauser, T., Jongma, B., Lopez, A., Mason, S., Mendler de Suarez, J., Pappenberger, F., Rueth, A., Stephens, E., Suarez, P., Wagemaker, J., & Zsoter, E. (2016). Action-based flood forecasting for triggering humanitarian action. *Hydrology and Earth System Sciences*, *20*(9), 3549–3560. https://doi.org/10.5194/hess-20-3549-2016

CRED. (2023). *EM-DAT | The international disasters database*. Retrieved March 21, 2023, from https://www.emdat.be/

CREWS. (n.d.). *Climate Risk and Early Warning Systems*. Retrieved March 9, 2023, from https://www.crews-initiative.org/en

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*(1), 100. https://doi.org/10.1186/1471-2288-11-100

Daniel, D., Diener, A., van de Vossenberg, J., Bhatta, M., & Marks, S. J. (2020). Assessing Drinking Water Quality at the Point of Collection and within Household Storage Containers in the Hilly Rural Areas of Mid and Far-Western Nepal. *International Journal of Environmental Research and Public Health*, *17*(7), 2172. https://doi.org/10.3390/ijerph17072172

Day, S. J. (2009). Community-based water resources management. *Waterlines*, *28*(1), 47–62. Retrieved February 16, 2023, from https://www.jstor.org/stable/24686845

dictionary of the English language, T. A. H. (2022). Drought. In *The American Heritage® Dictionary of the English Language* (Fifth Edition). Retrieved March 7, 2023, from https://ahdictionary.com/word/search.html?q=drought

Diggelen, W. van, & Overdijk, M. (2009). Grounded design: Design patterns as the link between theory and practice. *Computers in Human Behavior*, *25*(5), 1056–1066. https://doi.org/10.1016/j.chb.2009.01.005

DIPAS. (2023). *DIPAS.org | DIPAS*. Retrieved March 18, 2023, from https://dipas.org/

EDPS. (2023, March 30). *Glossary D | European Data Protection Supervisor*. Retrieved March 31, 2023, from https://edps.europa.eu/data-protection/data-protection/glossary/d_en

Emenike, C. P., Tenebe, I. T., Omole, D. O., Ngene, B. U., Oniemayin, B. I., Maxwell, O., & Onoka, B. I. (2017). Accessing safe drinking water in sub-Saharan Africa: Issues and challenges in South–West Nigeria. *Sustainable Cities and Society*, *30*, 263–272. https://doi.org/10.1016/j.scs.2017.01.005

Enenkel, M., Brown, M. E., Vogt, J. V., McCarty, J. L., Reid Bell, A., Guha-Sapir, D., Dorigo, W., Vasilaky, K., Svoboda, M., Bonifacio, R., Anderson, M., Funk, C., Osgood, D., Hain, C., & Vinck, P. (2020). Why predict climate hazards if we need to understand impacts? Putting humans back into the drought equation. *Climatic Change*, *162*(3), 1161–1176. https://doi.org/10.1007/s10584-020-02878-0

Erian, W., Pulwarty, R., Vogt, J. V., AbuZeid, K., Bert, F., Bruntrup, M., El-Askary, H., de Estrada, M., Gaupp, F., & Grundy, M. (2021). GAR special report on drought 2021.

ESCA. (2015). Ten Principles of Citizen Science. https://doi.org/10.17605/OSF.IO/XPR2NâĂİ Berlin.

ESCA, Haklay, M., Motion, A., Balázs, B., Kieslinger, B., Greshake Tzovaras, B., Nold, C., Dörler, D., Fraisl, D., Riemenschneider, D., Heigl, F., Brounéus, F., Hager, G., Heuer, K., Wagenknecht, K., Vohland, K., Shanley, L., Deveaux, L., Ceccaroni, L., . . . Wehn, U. (2020). ECSA's Characteristics of Citizen Science. https://doi.org/10.5281/zenodo.3758668

Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, swisstopo, & GIS User Community. (2023). *World Imagery - Overview*. Retrieved April 16, 2023, from https://www.arcgis.com/home/item.html?id=%2010df2279f9684e4a9f6a7f08febac2a9

eu-citizen.science. (n.d.). *EU-Citizen.Science*. Retrieved March 26, 2023, from https://eu-citizen.science/

Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989). Macro-scale water scarcity requires micro-scale approaches. *Natural Resources Forum*, *13*(4), 258–267. https://doi.org/10.1111/j.1477-8947.1989.tb00348.x

FAO. (2012). *Coping with water scarcity: An action framework for agriculture and food security* (P. Steduto, J.-M. Faurès, J. Hoogeveen, J. T. Winpenny, & J. J. Burke, Eds.). Food and Agriculture Organization of the United Nations.
OCLC: ocn822026893.

FAO & UN-Water. (2021, August 23). *Progress on the level of water stress*. Food and Agriculture Organization of the United Nations and UN-Water. https://doi.org/10.4060/cb6241en

FAO SWALIM. (n.d.). *Somalia Water and Land Information ManagementFAO SWALIM: Somalia Water and Land Information Management*. Retrieved October 26, 2022, from https://www.faoswalim.org/

FAOSWALIM. (2012). *Hydrogeological Survey and Assessment of Selected Areas in Somaliland and Puntland* (Technical Report No. W-20, FAO-SWALIM (GCP/SOM/049/EC)). Nairobi, Kenya.

FAOSWALIM. (2014). *SWALIM: Weather Monitoring*. Retrieved March 22, 2023, from http://www.faoswalim.org/water/climate/climate-data-collection

Ferreira, C., Andrade, P., & Almeida, F. (2020). How to Improve the Validity and Reliability of a Case Study Approach. *Journal of Interdisciplinary Studies in Education*, *9*, 273–284. https://doi.org/10.32674/jise.v9i2.2026

FEWSNET & USAID. (2023). *Famine Early Warning Systems Network*. Retrieved March 22, 2023, from https://fews.net/

Fienen, M. N., & Lowry, C. S. (2012). Social.Water—A crowdsourcing tool for environmental data acquisition. *Computers & Geosciences*, *49*, 164–169. https://doi.org/10.1016/j.cageo.2012.06.015

Filho, P. P., & Motta, H. O. D. (2021). *Democracy in Africa: The outstanding Case of Somaliland*. Retrieved October 25, 2022, from https://www.semanticscholar.org/paper/DEMOCRACY-IN-AFRICA%3A-THE-OUTSTANDING-CASE-OF-Filho-Motta/e8b2f10f6c5fbb794f2f88de1ba690b3a6952cf7

Fitzgerald, L. (1999). Case studies as a research tool. *Quality in health care : QHC*, *8*, 75. https://doi.org/10.1136/qshc.8.2.75

Forti, D. R. (2011). A Pocket of Stability: Understanding Somaliland, 49.

Fraisl, D., Hager, G., Bedessem, B., Gold, M., Hsing, P.-Y., Danielsen, F., Hitchcock, C. B., Hulbert, J. M., Piera, J., Spiers, H., Thiel, M., & Haklay, M. (2022). Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers*, *2*(1), 1–20. https://doi.org/10.1038/s43586-022-00144-4

Frigerio, S., Schenato, L., Bossi, G., Mantovani, M., Marcato, G., & Pasuto, A. (2018). Hands-On Experience of Crowdsourcing for Flood Risks. An Android Mobile Application Tested in Frederikssund, Denmark. *International Journal of Environmental Research and Public Health*, *15*(9), 1926. https://doi.org/10.3390/ijerph15091926

García, F. S., Pelacho, M., Woods, T., Fraisl, D., See, L., Haklay, M. M., & Arias, R. (2021). Finding what you need: A guide to citizen science guidelines. *The science of citizen science*, 419.

Gettliffe, E. (2021). UN OCHA anticipatory action. Lessons from the 2020 Somalia pilot.

Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strategic management journal*, *29*(13), 1465–1474.

Giordano, R., Preziosi, E., & Romano, E. (2013). Integration of local and scientific knowledge to support drought impact monitoring: Some hints from an Italian case study. *Natural Hazards*, *69*(1), 523–544. https://doi.org/10.1007/s11069-013-0724-9

Gladfelter, S. (2018). The politics of participation in community-based early warning systems: Building resilience or precarity through local roles in disseminating disaster information? *International Journal of Disaster Risk Reduction*, *30*, 120–131. https://doi.org/10.1016/j.ijdrr.2018.02.022

Gore, M., Abiodun, B., & Kucharski, F. (2020). Understanding the influence of ENSO patterns on drought over southern Africa using SPEEDY. *Climate Dynamics*, *54*. https://doi.org/10.1007/s00382-019-05002-w

GRC. (2017). Forecast-based Financing An innovative approach. https://www.drk.de/en/forecast-based-financing/

GRC, CVM, & IFRC. (2019). *2nd African Dialogue Platform on Forecast-based Financing*.

Grey, D., & Sadoff, C. W. (2007). Sink or Swim? Water security for growth and development. *Water Policy*, *9*(6), 545–571. https://doi.org/10.2166/wp.2007.021

Gualazzini, M. (2021). *EWEA: Early Warning Early action technical brief*.

Guenin, M.-J., De Nys, H. M., Peyre, M., Loire, E., Thongyuan, S., Diallo, A., Zogbelemou, L., & Goutard, F. L. (2022). A participatory epidemiological and One Health approach to explore the community's capacity to detect emerging zoonoses and surveillance network opportunities in the forest region of Guinea. *PLoS Neglected Tropical Diseases*, *16*(7), e0010462.

Guo, B., Yu, Z., Zhou, X., & Zhang, D. (2014). From participatory sensing to mobile crowd sensing. *2014 IEEE International Conference on Pervasive Computing and Communication Workshops (PERCOM WORKSHOPS)*, 593–598.

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., & Vohland, K. (2021). What Is Citizen Science? The Challenges of Definition. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, R. Samson, & K. Wagenknecht (Eds.), *The Science of Citizen Science* (pp. 13–33). Springer International Publishing. https://doi.org/10.1007/978-3-030-58278-4_2

Harkness, J., Bilgen, I., Cazar, A. C., Hu, M., Huang, L., Lee, S., Liu, M., Miller, D., Stange, M., Villar, A., & Yan, T. (2016). CCSG Questionnaire Design. Retrieved December 15, 2022, from https://ccsg.isr.umich.edu/chapters/questionnaire-design/

Harrowsmith, M., Nielsen, M., Sanchez, M. J., de Perez, E. C., Uprety, M., Johnson, C., van den Homberg, M., Tijssen, A., Page, E. M., & Lux, S. (2020). The Future of Forecast: Impact based Forecasting for Early Action.

Henriksen, H. J., Roberts, M. J., van der Keur, P., Harjanne, A., Egilson, D., & Alfonso, L. (2018). Participatory early warning and monitoring systems: A Nordic framework for web-based flood risk management. *International Journal of Disaster Risk Reduction*, *31*, 1295–1306. https://doi.org/10.1016/j.ijdrr.2018.01.038

Hillbruner, C., & Moloney, G. (2012). When early warning is not enough—Lessons learned from the 2011 Somalia Famine. *Global Food Security*, *1*(1), 20–28. https://doi.org/10.1016/j.gfs.2012.08.001

Howe, J. (2006). The Rise of Crowdsourcing [magazine]. *Wired*. Retrieved November 11, 2022, from https://www.wired.com/2006/06/crowds/

Huang, W. W., Chen, X. J., Fan, Y. R., & Li, Y. P. (2020). Management of Drinking Water Source in Rural Communities under Climate Change. *JOURNAL OF ENVIRONMENTAL INFORMATICS*, *39*(2), 136–151. Retrieved November 10, 2022, from http://www.jeionline.org/index.php?journal=mys&page=article&op=view&path%5B%5D=202000431

Ibrahim, K., Khodursky, S., & Yasseri, T. (2021). Gender Imbalance and Spatiotemporal Patterns of Contributions to Citizen Science Projects: The Case of Zooniverse. *Frontiers in Physics*, *9*. Retrieved April 12, 2023, from https://www.frontiersin.org/articles/10.3389/fphy.2021.650720

ICPAC. (2023). *Drought Indicators*. Retrieved March 13, 2023, from https://droughtwatch.icpac.net/drought-indicators/

ICPAC & WMO. (2023). *Delivering Climate Services to Eastern Africa*. ICPAC. Retrieved March 22, 2023, from https://www.icpac.net/

IDMP. (2021). *Indicators and Indices – Integrated Drought Management Programme*. Retrieved March 10, 2023, from https://www.droughtmanagement.info/indices/

IDMP. (2022). *Drought and Water Scarcity* (WMO No. 1284). Global Water Partnership, Stockholm, Sweden and and World Meteorological Organization, Geneva, Switzerland.

IFRC. (2017). Community-Based Surveillance: Guiding principles.

IFRC. (n.d.). *Community Engagement and Accountability | IFRC*. Retrieved September 15, 2022, from https://www.ifrc.org/community-engagement-and-accountability

IFRC & GRC. (2019). Forecast-based Financing A new era for the humanitarian system. https://www.forecast-based-financing.org/wp-content/uploads/2019/03/DRK_Broschuere_2019_new_era.pdf

IFRC, RCCC, & GRC. (2023a). *FbF Practitioners Manual*. Retrieved March 12, 2023, from https://manual.forecast-based-financing.org/en/

IFRC, RCCC, & GRC. (2023b). *FbF Practitioners Manual. Chapter 4.1 Set the Trigger*. Retrieved March 12, 2023, from https://manual.forecast-based-financing.org/en/chapter/set-the-trigger/

IFRC, RCCC, & GRC. (2023c). *FbF Practitioners Manual. Chapter 4.2 Select Early Actions*. Retrieved March 12, 2023, from https://manual.forecast-based-financing.org/en/chapter/select-early-actions/

IFRC, RCCC, & GRC. (2023d). *Glossary of Terms for Forecast-based Financing*. FbF Practitioners Manual. Retrieved March 12, 2023, from https://manual.forecast-based-financing.org/en/chapter/glossary/

Ighalo, J. O., & Adeniyi, A. G. (2020). A comprehensive review of water quality monitoring and assessment in Nigeria. *Chemosphere*, *260*, 127569. https://doi.org/10.1016/j.chemosphere.2020.127569

Inayath, C. M. (2018). Early Warning system and community based emergency response mechanism, 84.

IPCC. (2012). Glossary of Terms. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA.*, 555–564. https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf

IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. *Part A: global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental Panel on Climate Change*, *1132*.

Jarrett, P., Zadravecz, F. J., O'Keefe, J., Nshombo, M., Karume, A., & Roberts, L. (2020). Evaluation of a population mobility, mortality, and birth surveillance system in South Kivu, Democratic Republic of the Congo. *Disasters*, *44*(2), 390–407. https://doi.org/10.1111/disa.12370

Jung, J., Beledi, A. H., Riedel, N., Ahmed, A. O., & Larsen, T. M. (2022). Community Based Surveillance in Somaliland: Analysis of the Functionality and Effectiveness using the CBS Platform Nyss. *International Journal of Infectious Diseases*, *116*, S100. https://doi.org/10.1016/j.ijid.2021.12.236

Keough, H. L., & Blahna, D. J. (2006). Achieving integrative, collaborative ecosystem management. *Conservation Biology: The Journal of the Society for Conservation Biology*, *20*(5), 1373–1382. https://doi.org/10.1111/j.1523-1739.2006.00445.x

Khair, N. K. M., Lee, K. E., & Mokhtar, M. (2021). Community-based monitoring for environmental sustainability: A review of characteristics and the synthesis of criteria. *Journal of Environmental Management*, *289*, 112491. https://doi.org/10.1016/j.jenvman.2021.112491

Kim, J.-S., Park, S.-Y., Chen, J., Chen, S., Kim, T.-W., & Lee, J.-H. (2021). Integrated Drought Monitoring and Evaluation through Multi-Sensor Satellite-Based Statistical Simulation. *Remote Sensing*, *13*, 272. https://doi.org/10.3390/rs13020272

Kim, S., Robson, C., Zimmerman, T., Pierce, J., & Haber, E. M. (2011). Creek watch: Pairing usefulness and usability for successful citizen science. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2125–2134. https://doi.org/10.1145/1978942.1979251

Kirschke, S., Bennett, C., Bigham Ghazani, A., Franke, C., Kirschke, D., Lee, Y., Loghmani Khouzani, S. T., & Nath, S. (2022). Citizen science projects in freshwater monitoring. From individual design to clusters? *Journal of Environmental Management*, *309*, 114714. https://doi.org/10.1016/j.jenvman.2022.114714

Klemas, V., & Pieterse, A. (2015). Using Remote Sensing to Map and Monitor Water Resources in Arid and Semiarid Regions. In T. Younos & T. E. Parece (Eds.), *Advances in Watershed Science and Assessment* (pp. 33–60). Springer International Publishing. https://doi.org/10.1007/978-3-319-14212-8_2

Klobucista, C. (2018). *Somaliland: The Horn of Africa's Breakaway State*. Council on Foreign Relations. Retrieved March 21, 2023, from https://www.cfr.org/backgrounder/somaliland-horn-africas-breakaway-state

Kobo Organization. (n.d.). *KoboToolbox*. KoboToolbox. Retrieved March 20, 2023, from https://www.kobotoolbox.org/

Koehler, B., & Koontz, T. M. (2008). Citizen Participation in Collaborative Watershed Partnerships. *Environmental Management*, *41*(2), 143–154. https://doi.org/10.1007/s00267-007-9040-z

Kohlitz, J., Chong, J., & Willetts, J. (2020). Rural Drinking Water Safety under Climate Change: The Importance of Addressing Physical, Social, and Environmental Dimensions. *Resources*, *9*(6), 77. https://doi.org/10.3390/resources9060077

Kolen, B., Slomp, R., & Jonkman, S. (2013). The impacts of storm Xynthia February 27–28, 2010 in France: Lessons for flood risk management. *Journal of Flood Risk Management*, *6*(3), 261–278. https://doi.org/10.1111/jfr3.12011

Kullenberg, C., & Kasperowski, D. (2016). What Is Citizen Science? – A Scientometric Meta-Analysis. *PLOS ONE*, *11*(1), e0147152. https://doi.org/10.1371/journal.pone.0147152

Lackstrom, K., Farris, A., & Ward, R. (2022). Backyard Hydroclimatology: Citizen Scientists Contribute to Drought Detection and Monitoring. *Bulletin of the American Meteorological Society*, *-1*. https://doi.org/10.1175/BAMS-D-21-0157.1

Land-Zandstra, A., Agnello, G., & Gültekin, Y. S. (2021). Participants in Citizen Science. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, R. Samson, & K. Wagenknecht (Eds.), *The Science of Citizen Science* (pp. 243–259). Springer International Publishing. https://doi.org/10.1007/978-3-030-58278-4_13

Lawrimore, J. H., Wuertz, D., Wilson, A., Stevens, S., Menne, M., Korzeniewski, B., Palecki, M. A., Leeper, R. D., & Trunk, T. (2020). Quality Control and Processing of Cooperative Observer Program Hourly Precipitation Data. *Journal of Hydrometeorology*, *21*(8), 1811–1825. https://doi.org/10.1175/JHM-D-19-0300.1

Leal Filho, W., Barbir, J., Gwenzi, J., Ayal, D., Simpson, N. P., Adeleke, L., Tilahun, B., Chirisa, I., Gbedemah, S. F., Nzengya, D. M., Sharifi, A., Theodory, T., & Yaffa, S. (2022). The role of indigenous knowledge in climate change adaptation in Africa. *Environmental Science & Policy*, *136*, 250–260. https://doi.org/10.1016/j.envsci.2022.06.004

Leal Filho, W., Totin, E., Franke, J. A., Andrew, S. M., Abubakar, I. R., Azadi, H., Nunn, P. D., Ouweneel, B., Williams, P. A., & Simpson, N. P. (2022). Understanding responses to climate-related water scarcity in Africa. *Science of The Total Environment*, *806*, 150420. https://doi.org/10.1016/j.scitotenv.2021.150420

LeBaron, G., & National Audubon Society. (2022). *The 122nd Christmas Bird Count Summary*. Audubon. Retrieved March 18, 2023, from https://www.audubon.org/news/the-122nd-christmas-bird-count-summary

Lesotho Red Cross Society & IFRC. (2022). Early Action Protocol Summary Lesotho Drought EAP.

LIFE. (2017). *LIFE works with Local Village to Build Berkad*. Local Initiatives for Education (LIFE). Retrieved April 15, 2023, from http://localinitiativesforeducation.us/news/2017/11/16/life-works-with-local-village-to-build-berkad

Link, W. A., Sauer, J. R., & Niven, D. K. (2006). A Hierarchical Model for Regional Analysis of Population Change Using Christmas Bird Count Data, with Application to the American Black Duck. *The Condor*, *108*(1), 13–24. https://doi.org/10.1650/0010-5422(2006)108[0013:AHMFRA]2.0.CO;2

Liu, J., Shen, H., Narman, H. S., Chung, W., & Lin, Z. (2018). A Survey of Mobile Crowdsensing Techniques: A Critical Component for The Internet of Things. *ACM Transactions on Cyber-Physical Systems*, *2*(3), 18:1–18:26. https://doi.org/10.1145/3185504

Liu, J., Yang, H., Gosling, S. N., Kummu, M., Flörke, M., Pfister, S., Hanasaki, N., Wada, Y., Zhang, X., Zheng, C., Alcamo, J., & Oki, T. (2017). Water scarcity assessments in the past, present, and future. *Earth's Future*, *5*(6), 545–559. https://doi.org/10.1002/2016EF000518

Liu, J., & Zhao, D. (2020). Three-dimensional water scarcity assessment by considering water quantity, water quality, and environmental flow requirements: Review and prospect. *Chin. Sci. Bull*, *65*, 4251–4261.

Lopez, C. (2021). Motives for Citizen Science Program Participation and the Role of the Organization: Lessons from Water Quality Monitors in Texas. *Citizen Science: Theory and Practice*, *6*(1), 3. https://doi.org/10.5334/cstp.341

Lowry, C. S., Fienen, M. N., Hall, D. M., & Stepenuck, K. F. (2019). Growing Pains of Crowdsourced Stream Stage Monitoring Using Mobile Phones: The Development of CrowdHydrology. *Frontiers in Earth Science*, *7*. Retrieved October 21, 2022, from https://www.frontiersin.org/articles/10.3389/feart.2019.00128

Macherera, M., & Chimbari, M. J. (2016). A review of studies on community based early warning systems. *Jàmbá : Journal of Disaster Risk Studies*, *8*(1). https://doi.org/10.4102/jamba.v8i1.206

Mackechnie, C., Maskell, L., Norton, L., & Roy, D. (2011). The role of 'Big Society'in monitoring the state of the natural environment. *Journal of Environmental Monitoring*, *13*(10), 2687–2691.

Mafuta, W., Zuwarimwe, J., & Mwale, M. (2021). Universal WASH coverage; what it takes for fragile states. Case of Jariban district in Somalia. *PLOS ONE*, *16*, e0247417. https://doi.org/10.1371/journal.pone.0247417

Manalo, D. (2013). Bell and Bottle Technology: Community-based Early Warning System. *Agriculture and Development Notes*, *2*, 1–2. Retrieved September 28, 2022, from https://ideas.repec.org/a/sag/seaadn/2013237.html

Manifesto for Agile Software Development. (n.d.). Retrieved November 21, 2022, from http://agilemanifesto.org/

Mao, F., Khamis, K., Clark, J., Krause, S., Buytaert, W., Ochoa-Tocachi, B. F., & Hannah, D. M. (2020). Moving beyond the Technology: A Socio-technical Roadmap for Low-Cost Water Sensor Network Applications. *Environmental Science & Technology*, *54*(15), 9145–9158. https://doi.org/10.1021/acs.est.9b07125

Marchezini, V., Horita, F. E. A., Matsuo, P. M., Trajber, R., Trejo-Rangel, M. A., & Olivato, D. (2018). A Review of Studies on Participatory Early Warning Systems (P-EWS): Pathways to Support Citizen Science Initiatives. *Frontiers in Earth Science*, *6*. Retrieved September 28, 2022, from https://www.frontiersin.org/articles/10.3389/feart.2018.00184

Masinde, M. (2014). *An Effective Drought Early Warning System for Sub- Saharan Africa: Integrating Modern and Indigenous Approaches*. https://doi.org/10.1145/2664591.2664629

Masinde, M., & Bagula, A. (2010). A framework for predicting droughts in developing countries using sensor networks and mobile phones. *Proceedings of the 2010 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists*, 390–393. https://doi.org/10.1145/1899503.1899551

Masinde, M., & Bagula, A. (2012). ITIKI: Bridge between African indigenous knowledge and modern science of drought prediction. *Knowledge Management for Development Journal*, *7*(3), 274?290–274?290. Retrieved October 25, 2022, from https://www.km4djournal.org/index.php/km4dj/article/view/455

Masinde, M., Bagula, A., & Muthama, N. (2013). Implementation roadmap for downscaling drought forecasts in Mbeere using ITIKI. *2013 Proceedings of ITU Kaleidoscope: Building Sustainable Communities*, 1–8.

Masinde, M., Mwagha, S., & Tadesse, T. (2018). Downscaling Africa's Drought Forecasts through Integration of Indigenous and Scientific Drought Forecasts Using Fuzzy Cognitive Maps. *Geosciences*, *8*, 135. https://doi.org/10.3390/geosciences8040135

Masinde, M., & Thothela, P. N. (2019). ITIKI Plus: A Mobile Based Application for Integrating Indigenous Knowledge and Scientific Agro-Climate Decision Support for Africa's Small-Scale Farmers. *2019 IEEE 2nd International Conference on Information and Computer Technologies (ICICT)*, 303–309. https://doi.org/10.1109/INFOCT.2019.8711059

McGowan, C. R., Takahashi, E., Romig, L., Bertram, K., Kadir, A., Cummings, R., & Cardinal, L. J. (2022). Community-based surveillance of infectious diseases: A systematic review of drivers of success. *BMJ global health*, *7*(8), e009934. https://doi.org/10.1136/bmjgh-2022-009934

McNeil, C., Verlander, S., Divi, N., & Smolinski, M. (2022). The Landscape of Participatory Surveillance Systems Across the One Health Spectrum: Systematic Review. *JMIR Public Health and Surveillance*, *8*(8), e38551. https://doi.org/10.2196/38551

Mercy Corps. (2017). Improved Berkad Designs by Mercy Corps - Somalia.

Metuge, A., Omam, L.-A., Jarman, E., & Njomo, E. O. (2021). Humanitarian led community-based surveillance: Case study in Ekondo-titi, Cameroon. *Conflict and Health*, *15*(1), 17. https://doi.org/10.1186/s13031-021-00354-9

Minkman, E. (2015). Citizen Science in Water Quality Monitoring: Developing Guidelines for Dutch Water Authorities for Contributory Mobile Crowd Sensing. Retrieved October 21, 2022, from https://repository.tudelft.nl/islandora/object/uuid%3A3850a8ec-d6aa-4f7d-a3ae-2f48f53cc148

Mishra, B. K., Kumar, P., Saraswat, C., Chakraborty, S., & Gautam, A. (2021). Water Security in a Changing Environment: Concept, Challenges and Solutions. *Water*, *13*(4), 490. https://doi.org/10.3390/w13040490

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (n.d.). Unaffordable and Undrinkable: 2019.

Mloza-Banda, C., & Scholtz, B. (2018). Crowdsensing for successful water resource monitoring: An analysis of citizens' intentions and motivations. *Proceedings of the Annual Conference of the South African Institute of Computer Scientists and Information Technologists*, 55–64. https://doi.org/10.1145/3278681.3278688

Molden, D., Institute, I. W. M., & of Water Management in Agriculture (Program), C. A. (Eds.). (2007). *Water for food, water for life: A comprehensive assessment of water management in agriculture*. Earthscan.
OCLC: ocm71285428.

Moriarty, P., Butterworth, J., & Batchelor, C. (2004). Integrated Water Resources Management and the Domestic Water and Sanitation Sub-Sector. Thematic Overview Paper. *Netherlands: IRC International Water and Sanitation Centre*.

Musei, S. K., Nyaga, J. M., & Dubow, A. Z. (2021). SPEI-based spatial and temporal evaluation of drought in Somalia. *Journal of Arid Environments*, *184*, 104296. https://doi.org/10.1016/j.jaridenv.2020.104296

National Drought Committee. (2022). *Somaliland Drought Rapid Assessment Report*. Retrieved March 1, 2023, from https://drive.google.com/file/d/1KWUZW0jEMV1Ijc4zeET_Yes93VJ_3qn2/view?usp=embed_facebook

NCAR. (n.d.-a). *Standardized Precipitation Evapotranspiration Index (SPEI)*. Retrieved March 10, 2023, from climatedataguide.ucar.edu/climate-data/standardized-precipitation-evapotranspiration-index-spei

NCAR. (n.d.-b). *Standardized Precipitation Index (SPI)*. Retrieved March 10, 2023, from climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi

NDMC. (2023a). Types of Drought. In *National Drought Mitigation Center*. University of Nebraska-Lincoln. Retrieved March 7, 2023, from https://drought.unl.edu/Education/DroughtIn-depth/TypesofDrought.aspx

NDMC. (2023b). What is Drought? In *National Drought Mitigation Center*. University of Nebraska-Lincoln. Retrieved March 6, 2023, from https://drought.unl.edu/Education/DroughtIn-depth/WhatisDrought.aspx

NIDIS. (2023). *Outlooks & Forecasts*. Drought.gov. Retrieved March 13, 2023, from https://www.drought.gov/forecasts

Nikolay, B., Salje, H., Sturm-Ramirez, K., Azziz-Baumgartner, E., Homaira, N., Ahmed, M., Iuliano, A. D., Paul, R. C., Rahman, M., Hossain, M. J., Luby, S. P., Cauchemez, S., & Gurley, E. S. (2017). Evaluating Hospital-Based Surveillance for Outbreak Detection in Bangladesh: Analysis of Healthcare Utilization Data. *PLOS Medicine*, *14*(1), e1002218. https://doi.org/10.1371/journal.pmed.1002218

Njambi-Szlapka, S., & Jones, A. (n.d.). *Integrating community voices in anticipatory action: A synthesis of complex qualitative data*. Anticipation Hub. Retrieved November 2, 2022, from https://www.anticipation-hub.org/news/integrating-community-voices-in-anticipatory-action-a-synthesis-of-complex-qualitative-data

Noureen, J., & Asif, M. (2017). Crowdsensing: Socio-Technical Challenges and Opportunities. *International Journal of Advanced Computer Science and Applications*, *8*(3). https://doi.org/10.14569/IJACSA.2017.080351

NRC. (2023). *Nyss: A tool developed with the Red Cross for Community-Based Surveillance*. Retrieved October 26, 2022, from https://github.com/nyss-platform-norcross/nyss

NRC & IFRC. (2021). NYSS a community-based surveillance platform. User manual.

NRC & IFRC. (2023). *What is Nyss*. Retrieved March 22, 2023, from https://www.cbsrc.org/what-is-nyss

Nyetanyane, J., & Masinde, M. (2020). Integration of Indigenous Knowledge, Climate Data, Satellite Imagery and Machine Learning to Optimize Cropping Decisions by Small-Scale Farmers. a Case Study of uMgungundlovu District Municipality, South Africa. In J. P. R. Thorn, A. Gueye, & A. P. Hejnowicz (Eds.), *Innovations and Interdisciplinary Solutions for Underserved Areas* (pp. 3–19). Springer International Publishing. https://doi.org/10.1007/978-3-030-51051-0_1

Obeng-Odoom, F. (2012). Beyond access to water. *Development in Practice*, *22*(8), 1135–1146. https://doi.org/10.1080/09614524.2012.714744

Observatory, E. D. (2017). Drought Indicators. Retrieved March 10, 2023, from https://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1010

OCHA. (2020). ANTICIPATORY ACTION PLAN For Drought in Somalia.

OpenAI. (2022). *Introducing Whisper*. Retrieved March 25, 2023, from https://openai.com/research/whisper

OpenAI. (2023). *Whisper*. Retrieved March 25, 2023, from https://github.com/openai/whisper

Oxfam. (2009). Introduction to Community-Based Water Resource Management: A Learning Companion Oxfam Disaster Risk Reduction and Climate Change Adaptation Resources. https://www.oxfamwash.org/water/cbwrm/Oxfam%20CBWRM%20Companion,%202009.pdf

Palmer, W. C. (1965). *Meteorological Drought*. U.S. Department of Commerce, Weather Bureau.

Pateman, R. M., Dyke, A., & West, S. E. (2021). The Diversity of Participants in Environmental Citizen Science. *Citizen Science: Theory and Practice*. Retrieved April 12, 2023, from https://doi.org/10.5334/cstp.369

Peifer, D. C. (2009, May). *Stopping Mass Killings in Africa: Genocide, Airpower, and Intervention*. DIANE Publishing.

Pelz, B. (n.d.). *Research Methods for the Social Sciences*. ORS services Lumen Learnings. Retrieved March 24, 2023, from https://courses.lumenlearning.com/suny-hccc-research-methods/

Petrucci, B. (2022). Landscape and Landforms of Northern Somalia. In P. Billi (Ed.), *Landscapes and Landforms of the Horn of Africa: Eritrea, Djibouti, Somalia* (pp. 233–247). Springer International Publishing. https://doi.org/10.1007/978-3-031-05487-7_10

Pettibone, L., Vohland, K., Bonn, A., Richter, A., Bauhus, W., Behrisch, B., Borcherding, R., Brandt, M., Bry, F., Dörler, D., Elbertse, I., Glöckler, F., Göbel, C., Hecker, S., Heigl, F., Herdick, M., Kiefer, S., Kluttig, T., Kühn, E., & Ziegler, D. (2016, July 1). *Citizen science for all. A guide for citizen science practitioners*.

Pineda, M. V. G. (2015). Redefining Community Based Disaster Risk Management (CBDRM) through Enhanced Early Warning Processes. *International Journal of Information and Education Technology*, *5*(7), 543–548. https://doi.org/10.7763/IJIET.2015.V5.565

Pocock, M. J. O., Chapman, D. S., Sheppard, L. J., & Roy, H. E. (2014). A Strategic Framework to Support the Implementation of Citizen Science for Environmental Monitoring, 67.

Quinn, P., Jasmontaite, L., Barboza, J. Z., Riedel, N., & Larsen, T. M. (2020). *Nyss - Data protection assessment report*. NRC & BRC.

Rädiker, S. (2020). Focused analysis of qualitative interviews with MAXQDA: Step by step.

Ratnayake, R., Finger, F., Edmunds, W. J., & Checchi, F. (2020). Early detection of cholera epidemics to support control in fragile states: Estimation of delays and potential epidemic sizes. *BMC Medicine*, *18*(1), 397. https://doi.org/10.1186/s12916-020-01865-7

Ratnayake, R., Tammaro, M., Tiffany, A., Kongelf, A., Polonsky, J. A., & McClelland, A. (2020). People-centred surveillance: A narrative review of community-based surveillance among crisis-affected populations. *The Lancet Planetary Health*, *4*(10), e483–e495. https://doi.org/10.1016/S2542-5196(20)30221-7

RCRC. (2020). *Forecast-based Financing and Early Action for Drought*.

Renn, O. (2006). Participatory processes for designing environmental policies. *Land Use Policy*, *23*(1), 34–43. https://doi.org/10.1016/j.landusepol.2004.08.005

Republic of Somalia. (2021). Republic of Somaliland Country Profile 2021.

Republic of Somaliland. (2019). Regions and Districts Self-management Law, No. 23/2019.

Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., Lewis, D., & Jacobs, D. (2012). Dynamic changes in motivation in collaborative citizen-science projects. *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*, 217–226. https://doi.org/10.1145/2145204.2145238

Rüth, A., Siahaan, K. D., Coughlan, E., Kelly, T., Jaime, C., Bailey, M., & Lux, S. (2017). Forecast-based financing: A policy overview.

Rutten, M., Minkman, E., & van der Sanden, M. (2017). How to get and keep citizens involved in mobile crowd sensing for water management? A review of key success factors and motivational aspects. *WIREs Water*, *4*(4), e1218. https://doi.org/10.1002/wat2.1218

Sadoff, C., Grey, D., & Borgomeo, E. (2020). *Water Security*. Oxford Research Encyclopedia of Environmental Science. https://doi.org/10.1093/acrefore/9780199389414.013.609

Sahana Foundation. (2016, October 27). *Sahana EDEN*. Sahana Foundation. Retrieved March 20, 2023, from https://sahanafoundation.org/eden/

Salem, U. (2016). *Territorial diagnostic report of the land resources of Somaliland*. FAO-SWALIM. Nairobi, Kenya.

San Llorente Capdevila, A., Kokimova, A., Sinha Ray, S., Avellán, T., Kim, J., & Kirschke, S. (2020). Success factors for citizen science projects in water quality monitoring. *Science of The Total Environment*, *728*, 137843. https://doi.org/10.1016/j.scitotenv.2020.137843

Sauermann, H., & Franzoni, C. (2015). Crowd science user contribution patterns and their implications. *Proceedings of the National Academy of Sciences*, *112*(3), 679–684. https://doi.org/10.1073/pnas.1408907112

SCRS. (2022). *Feasibility Study on Potential Use of Forecast-based Financing (FbF) for SRCS*. Nottawasaga Institute.

Senay, G. B., Velpuri, N. M., Alemu, H., Md Pervez, S., Asante, K. O., Kariuki, G., Taa, A., & Angerer, J. (2013). Establishing an operational waterhole monitoring system using satellite data and hydrologic modelling: Application in the pastoral regions of East Africa. *Pastoralism: Research, Policy and Practice*, *3*, 1–16.

Sharpe, A., & Conrad, C. (2006). Community based ecological monitoring in Nova Scotia: Challenges and opportunities. *Environmental monitoring and assessment*, *113*, 395–409.

Shirk, J., Ballard, H., Wilderman, C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B., Krasny, M., & Bonney, R. (2012). Public Participation in Scientific Research: A Framework for Deliberate Design. *Ecology and Society*, *17*(2). https://doi.org/10.5751/ES-04705-170229

Siahaan, K. D. (2018). Forecast-based Action by the DREF. https://www.forecast-based-financing.org/wp-content/uploads/2018/10/DRK_Broschuere_FUND_Web_ENG.pdf

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, *24*(9), 467–471. https://doi.org/10.1016/j.tree.2009.03.017

Skarlatidou, A., Hamilton, A., Vitos, M., & Haklay, M. (2019). What do volunteers want from citizen science technologies? A systematic literature review and best practice guidelines. *JCOM: Journal of Science Communication*, *18*(1). Retrieved November 11, 2022, from https://doi.org/10.22323/2.18010202

Smith, P. J., Brown, S., & Dugar, S. (2017). Community-based early warning systems for flood risk mitigation in Nepal. *Natural Hazards and Earth System Sciences*, *17*(3), 423–437. https://doi.org/10.5194/nhess-17-423-2017

Society, N. R. C., & IFRC. (2021). Niger: Drought Early Action Protocol summary.

Speir, S. L., Shang, L., Bolster, D., Tank, J. L., Stoffel, C. J., Wood, D. M., Peters, B. W., Wei, N., & Wang, D. (2022). Solutions to Current Challenges in Widespread Monitoring of Groundwater Quality via Crowdsensing. *Groundwater*, *60*(1), 15–24. https://doi.org/10.1111/gwat.13150

SRCS. (2021). *DRM Strategic Plan final*. Google Docs. Retrieved February 18, 2023, from https://drive.google.com/file/d/17E7ZwAsWHYaxfMPzD9WZK9n6yYsH5L2j/view?usp=embed_facebook

Srivastava, P., & Hopwood, N. (2009). A Practical Iterative Framework for Qualitative Data Analysis. *International Journal of Qualitative Methods*, *8*(1), 76–84. https://doi.org/10.1177/160940690900800107

Srivastava, S., Vaddadi, S., & Sadistap, S. (2018). Smartphone-based System for water quality analysis. *Applied Water Science*, *8*. https://doi.org/10.1007/s13201-018-0780-0

Starkey, E., Parkin, G., Birkinshaw, S., Large, A., Quinn, P., & Gibson, C. (2017). Demonstrating the value of community-based ('citizen science') observations for catchment modelling and characterisation. *Journal of Hydrology*, *548*, 801–817. https://doi.org/10.1016/j.jhydrol.2017.03.019

Stephens, E., Coughlan de Perez, E., Kruczkiewicz, A., Boyd, E., & Suarez, P. (2015). FORECASTBASED ACTION.

Sullivan, C., Meigh, J., & Giacomello, A. (2003). The Water Poverty Index: Development and application at the community scale. *Natural Resources Forum*, *27*(3), 189–199. https://doi.org/10.1111/1477-8947.00054

Svoboda, M., Fuchs, B., & IDMP. (2016). Handbook of Drought Indicators and Indices.

SWALIM. (2016). *Somalia Assorted Settlements*. GeoNode. Retrieved October 26, 2022, from https://spatial.faoswalim.org/layers/geonode:SOM_settlements_ASSORTED

SWALIM. (2019). *Administrative Districts of Somalia*. Retrieved April 16, 2023, from https://spatial.faoswalim.org/layers/geonode:SOM_Adminbnda_Adm3_Districts_UNOCHA

SWALIM. (n.d.). *Somalia Water Sources*. GeoNode. Retrieved October 26, 2022, from https://spatial.faoswalim.org/layers/

SWALM. (2023). *Somalia Water Sources Information Management System*. Retrieved September 23, 2022, from https://swims.faoswalim.org/livemap/view#

Swanson, W., Walters, L., Wilton, P., & Nyakairu, F. (2022, December 13). *Nearly 8.3 million people across Somalia face Crisis (IPC Phase 3) or worse acute food insecurity outcomes*. OCHA. Retrieved March 21, 2023, from https://reliefweb.int/report/somalia/nearly-83-million-people-across-somalia-face-crisis-ipc-phase-3-or-worse-acute-food-insecurity-outcomes

Tarchiani, V., Massazza, G., Rosso, M., Tiepolo, M., Pezzoli, A., Housseini Ibrahim, M., Katiellou, G. L., Tamagnone, P., De Filippis, T., Rocchi, L., Marchi, V., & Rapisardi, E. (2020). Community and Impact Based Early Warning System for Flood Risk Preparedness: The Experience of the Sirba River in Niger. *Sustainability*, *12*(5), 1802. https://doi.org/10.3390/su12051802

Tariq, M. O., Siddiq, A., Irshad, H., Aman, M., & Khan, M. S. (2021). An Open Source Water Quality Measurement System for Remote Areas. *Engineering Proceedings*, *12*(1), 50. https://doi.org/10.3390/engproc2021012050

Technical Contributors to the June 2018 WHO meeting. (2019). A definition for community-based surveillance and a way forward: Results of the WHO global technical meeting, France, 26 to 28 June 2018. *Euro Surveillance: Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin*, *24*(2), 1800681. https://doi.org/10.2807/1560-7917.ES.2019.24.2.1800681

The Pharo Foundation. (2020). *Improved Berkad*. Retrieved April 15, 2023, from www.pharofoundation.org/wp-content/uploads/2020/02/Ilma-Dado-Berkad-1-scaled.jpg

Thomson, P. (2021). Remote monitoring of rural water systems: A pathway to improved performance and sustainability? *WIREs Water*, *8*(2), e1502. https://doi.org/10.1002/wat2.1502

Thothela, P., Markus, E., Masinde, M., & Abu-Mahfouz, A. (2021). A Survey of Intelligent Agro-climate Decision Support Tool for Small-Scale Farmers: An Integration of Indigenous Knowledge, Mobile Phone Technology and Smart Sensors. https://doi.org/10.1007/978-981-15-8354-4_71

Tipaldo, G., & Allamano, P. (2017). Citizen science and community-based rain monitoring initiatives: An interdisciplinary approach across sociology and water science. *WIREs Water*, *4*(2), e1200. https://doi.org/10.1002/wat2.1200

Trisos, C., Adelekan, I., Totin, E., Christopher, T., Ayanlade, S., Efitre, J., Adugna, G., Kalaba, F., Lennard, C., Catherine, M., Mgaya, Y., Grace, N., Daniel, O., Sumaya, Z., & Simpson, N. (2022, December 31). Africa. In H.-O. Pörtner, D.C. Roberts, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1285–145). Cambridge University Press, Cambridge, UK and New York, NY, USA. doi:10.1017/9781009325844.011

Trogrlić, R., & van den Homberg, M. (2018, September 17). *Indigenous knowledge and early warning systems in the Lower Shire Valley in Malawi*.

UN. (2016). *Goal 6 | Ensure availability and sustainable management of water and sanitation for all*. Retrieved April 7, 2023, from https://sdgs.un.org/goals/goal6

UNDRR. (2015). Sendai Framework for Disaster Risk Reduction 2015 - 2030.

UNDRR. (2021). *Special report on drought 2021*. United Nations.

UNISDR. (2005). Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters.

UNISDR. (2009). UNISDR terminology on disaster risk reduction. *Geneva: United Nations*.

United Nations. (2002). *Deepening democracy in a fragmented world*. Oxford Univ. Press.

United Nations Children's Fund (UNICEF) and World Health & World Health Organization. (2018). *Core questions on water, sanitation and hygiene for household surveys: 2018 update*. New York, NY, USA.

United Nations University. (2017). Too Many Indicators and Indices Make Monitoring Water Quality a Murky Business. Retrieved March 10, 2023, from https://flores.unu.edu/en/news/news/too-many-indicators-and-indices-make-monitoring-water-quality-a-murky-business.html#info

USAID. (2018). Economics of Resilience to Drought: Somalia Analysis.

Ushahidi. (n.d.). *Crowdsourcing Solutions to Empower Communities*. Ushahidi. Retrieved March 20, 2023, from https://www.ushahidi.com//

Van Beek, E., & Arriens, W. L. (2014). *Water security: Putting the concept into practice*. Global Water Partnership Stockholm.

Van Loon, A. F., Stahl, K., Di Baldassarre, G., Clark, J., Rangecroft, S., Wanders, N., Gleeson, T., Van Dijk, A. I. J. M., Tallaksen, L. M., Hannaford, J., Uijlenhoet, R., Teuling, A. J., Hannah, D. M., Sheffield, J., Svoboda, M., Verbeiren, B., Wagener, T., & Van Lanen, H. A. J. (2016). Drought in a human-modified world: Reframing drought definitions, understanding, and analysis approaches. *Hydrology and Earth System Sciences*, *20*(9), 3631–3650. https://doi.org/10.5194/hess-20-3631-2016

Vhumbunu, C. H. (2021). Counting Down to Day Zero: Exploring Community-Based Water Management Strategies in Western Cape Province Drought, South Africa (2017/2018). In R. Djalante, M. B. F. Bisri, & R. Shaw (Eds.), *Integrated Research on Disaster Risks: Contributions from the IRDR Young Scientists Programme* (pp. 193–212). Springer International Publishing. https://doi.org/10.1007/978-3-030-55563-4_11

Walker, D. W., Smigaj, M., & Tani, M. (2021). The benefits and negative impacts of citizen science applications to water as experienced by participants and communities. *WIREs Water*, *8*(1), e1488. https://doi.org/10.1002/wat2.1488

Walker, R., & Sugule. (1998). Changing Pastoralism in the Ethiopian Somali National Regional State (Region 5). Retrieved December 14, 2022, from https://www.africa.upenn.edu/Hornet/past0698.html

Wang, H. (2022). A Survey of Application and Key Techniques for Mobile Crowdsensing. *Wireless Communications and Mobile Computing*, *2022*, e3693537. https://doi.org/10.1155/2022/3693537

Wang, W., Ertsen, M. W., Svoboda, M. D., & Hafeez, M. (2016). Propagation of Drought: From Meteorological Drought to Agricultural and Hydrological Drought. *Advances in Meteorology*, *2016*, e6547209. https://doi.org/10.1155/2016/6547209

Weeser, B., Stenfert Kroese, J., Jacobs, S. R., Njue, N., Kemboi, Z., Ran, A., Rufino, M. C., & Breuer, L. (2018). Citizen science pioneers in Kenya – A crowdsourced approach for hydrological monitoring. *Science of The Total Environment*, *631–632*, 1590–1599. https://doi.org/10.1016/j.scitotenv.2018.03.130

WEF. (2009). The bubble is close to bursting: A forecast of the main economic and geopolitical water issues likely to arise in the world during the next two decades. *World Economic Forum.< http://www. Weforum. Org/Pdf/Water/WaterInitiativeFutureWaterNeeds. Pdf>(Accessed 09.03. 10)*.

Weston, S., & Conrad, C. (2015). Community-Based Water Monitoring in Nova Scotia: Solutions for Sustainable Watershed Management. *Environment and Natural Resources Research*, *5*(2), p1. https://doi.org/10.5539/enrr.v5n2p1

WFP, Gros, C., Kazis, P., & Mason, J. (2021). Monitoring and evaluation of anticipatory actions for drought: Guidance and tools for Forecast-based Financing programmes.

Whitelaw, G., Vaughan, H., Craig, B., & Atkinson, D. (2003). Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment*, *88*(1), 409–418. https://doi.org/10.1023/A:1025545813057

Wiegers, K., & Beatty, J. (2013). *Software requirements*. Pearson Education.

Wilhite, D. A., & Glantz, M. H. (1985). Understanding: The Drought Phenomenon: The Role of Definitions. *Water International*, *10*(3), 111–120. https://doi.org/10.1080/02508068508686328

Williams, M., & Eggleston, S. (2017). Using indicators to explain our changing climate to policymakers and the public. Retrieved March 10, 2023, from https://public.wmo.int/en/resources/bulletin/using-indicators-explain-our-changing-climate-policymakers-and-public

Wilson-Jones, T., & Rivett, U. (2012). Using Mobile Phones to Monitor and Manage Water Supply Quality in Rural Environments. *WISA 2012 Biennial Conference and Exhibition*.

WMO (Ed.). (2013). *Planning of water-quality monitoring systems*. World Meteorological Organization.

World Bank. (1997). *World Development Report 1997: The State in a Changing World.* New York: Oxford University Press. https://doi.org/10.1596/978-0-1952-1114-6

World Bank. (2014). *New World Bank GDP and Poverty Estimates for Somaliland*. World Bank. Retrieved March 21, 2023, from https://www.worldbank.org/en/news/press-release/2014/01/29/new-world-bank-gdp-and-poverty-estimates-for-somaliland

World Bank. (2016). *High and Dry: Climate Change, Water, and the Economy*. World Bank. Washington, DC. Retrieved March 8, 2023, from https://www.worldbank.org/en/topic/water/publication/high-and-dry-climate-change-water-and-the-economy

World Bank. (n.d.). *Global Risk Financing Facility*. World Bank. Retrieved March 9, 2023, from https://www.worldbank.org/en/topic/disasterriskmanagement/brief/global-risk-financing-facility

Yin, R. (1984). Case Study Research: Design and Methods.

Young, R. R. (2001). *Effective requirements practices*. Addison-Wesley Longman Publishing Co., Inc.

Young, R. R. (2006). *Project requirements: A guide to best practices*. Berrett-Koehler Publishers.

Yuan, Y., Yang, H., Zhou, W., & Li, C. (2008). Influences of the Indian Ocean dipole on the Asian summer monsoon in the following year. *International Journal of Climatology: A Journal of the Royal Meteorological Society*, *28*(14), 1849–1859.

Zainal, Z. (2007). Case study as a research method, 6.

Zamxaka, M., Pironcheva, G., & Muyima, N. Y. O. (2004). Microbiological and physico-chemical assessment of the quality of domestic water sources in selected rural communities of the Eastern Cape Province, South Africa. *Water SA*, *30*(3), 333–340. https://doi.org/10.4314/wsa.v30i3.5081

Zheng, F., Tao, R., Maier, H. R., See, L., Savic, D., Zhang, T., Chen, Q., Assumpção, T. H., Yang, P., Heidari, B., Rieckermann, J., Minsker, B., Bi, W., Cai, X., Solomatine, D., & Popescu, I. (2018). Crowdsourcing Methods for Data Collection in Geophysics: State of the Art, Issues, and Future Directions. *Reviews of Geophysics*, *56*(4), 698–740. https://doi.org/10.1029/2018RG000616

Appendix A

Appendix A: GitHub Repository

Please see the git repository at github.com/BoSott/masterthesis for all resources used in this thesis. Here, in addition to the following appendices, the developed figures are provided together with the questionnaires, interview transcripts and data used.

Appendix B

Appendix B: Questionnaires and Interview Guidelines

The transcripts of the interviews are listed together with the questions chronologically in the order in which the interviews were conducted.

B.1 Questionnaire & Answers I1

Interviewer: Bosse Sottmann
Medium: Google Forms
Interviewee: GRC FbF Manager of the SRCS
Date: 31.01.2023

Questionnaire SRCS: Defining Goals and Outcomes

Introduction
The goal of this project is the design of a practically applicable volunteer sensing-based water source monitoring approach primarily for the water source type of Berkads. Sub-goals are based on the learnings how water access can be measured specifically for this water source type, what information needs to be known about the source initially, continuously and if the incorporation of local knowledge is useful and possible – and if yes, how and which specific information are helpful in the context of Anticipatory Actions.
The work will be based on a variety of different sources of information. In addition to this questionnaire and subsequent discussions, also with other stakeholders, best practices and knowledge will be gathered from the literature. Therefore, your input to this questionnaire is critical in multiple ways. Your and the SRCSs opinions, experiences and needs will be the foundation for all of the following work - ensuring that the resulting design meets your requirements and that it aligns to the constraints of this context. Based on the defined goals and following results you will mention here, best practices and knowledge from other contexts can be transferred and applied to this project.
Methodologically, this project coarsely follows the 7-layer-Model of Collaboration. We start to define goals, sub-goals and the actual results we need to accomplish in order to reach these

goals. Further down the road, we will build on top of this by defining sets of actions to accomplish the results, thinking about patterns of collaboration internally and with other stakeholders and further defining specific techniques, tools and scripts. Thus, creating a design, that is adapted to the specific context and at the same time applies current best practices from around the world. Nonetheless, a disclaimer should be made, that this is a project in the context of a Master's thesis, thus a fully-fledged design ready to get launched is out of scope of this work. Yet, it can lay a good foundation for the following work.

General questions

Please give some brief information about yourself and about your organization.

What is your role in the SRCS?
Offering technical support to the ongoing Forecast based Financing project

How long have you worked in your position?
1 year

What are your predominant tasks?
Offering technical support to the ongoing Forecast based Financing project as well coordinating the partnership between SRCS and the German Red Cross

How many paid employees does the SRCS have in total?
249

How many of those work in the sector of risk management and/or Anticipatory Actions?
30

How many volunteers does the SRCS have?
1500

How are the Volunteers spread across the country? Are there regions where there are essentially no or fewer volunteers?
The Volunteers are evenly spread across the country. However some regions have inactive volunteers due to less activities there whilst some regions have active volunteers due to the amount of project work being undertaken there

Goals of the project

This section is about the main and sub-goals of this project. A main goal could be the mapping of accessible water sources, whereas a sub-goal of this could be e.g. the training and education of volunteers for this task. Please think creatively, without the restriction of limiting resources and please also think about related fields that can be (indirectly) affected by this.
What are the main goals for the project of mapping and monitoring water sources from the perspective of the SRCS? What do you ultimately want to achieve?
Location is key! Berkads location data is currently missing and this has resulted in the SRCS not being able to quantify the number of existing berkads per region. The main goal of the project will be

ascertain the location of berkads and capturing key info such as berkad ownership status (some berkads are privately owned thus not everyone can access water from them. Important info to be also captured include the total number of people or communities dependant on the berkad as well as the storage capacity of the Berkad. Monitoring of water sources would enable seamless prioritization of regions to deliver water (water trucking). Ultimately, in terms of Anticipatory Actions water sources monitoring would enable triggering action before critical water levels

Can you think of sub-goals that would go along with each main goal?

Can you think of additional goals from the perspective of the community or volunteer potentially involved in the project?
From the community/volunteer perspective the main goal would be for them to know the existing water resources within their vicinity, as well as the capacity of these water bodies. The main goal being to ascertain whether these water bodies are able to withstand the demand during drought periods.

Which of these goals could match well and which might be competing?
The community and SRCS goals match as both focus on closing the knowledge currently existing regarding berkads numbers per district, community and regional level

Wanted results

In order to fulfil the defined goals, it is important to further specify actual outcomes by the project. These may deal with issues of quality, effectiveness, efficiency, and other product related characteristics. Following the example from above, this could be a collection of data about water sources in the project area meeting certain pre-defined quality standards. Another result for the sub-goal of trained volunteers might be a collection of appropriate training materials. What results must be achieved in order to reach the goals? Please list them.
i) Location data of the berkads (coordinates),
ii)Volunteer orientation on water resources monitoring
iii) determining the ownership status of each berkad
iv) community sensitization to dispel misconceptions about the mapping and water monitoring exercise
v) water levels monitoring
vi) triggering action based on water levels
vii) Determining the water level trigger

Which of those results do you consider to be the most critical? Please list them and if possible, explain why.
Location data as this will enable determine the serving capacity of each berkad i.e the total number of communities dependant on each berkad. One important result is also community sensitisation to dispel misconceptions within the communtiies. The community will need to understand why the SRCS will be monitoring water bodies. Triggering for action is also a key result as the end goal will be to counter water shortages so as to mitigate water shortages.

Based on your experience - in which chronological order do the results have to be processed? Please order them accordingly and add some explanation if possible.

i) Volunteer orientation on water resources monitoring
ii) community sensitization to dispel misconceptions about the mapping and water monitoring exercise
iii) Location data of the berkads (coordinates)
iv) determining the ownership status of each berkad
v) Determining the water level trigger
vi) water levels monitoring
vii) triggering action based on water levels

Which of the results specifically required in the design phase do you think are the most critical?
Determining the water levels to trigger action.

Which results would specifically be required to address Anticipatory Actions?
i) Determining the water level to trigger action
ii) water levels monitoring
iii) triggering action based on water levels

Stakeholders

One of the key success factors for a successful design and implementation of a crowdsensing project mentioned in the literature is the early inclusion of all involved stakeholders. This section is about them. What stakeholders are involved in the mapping and monitoring of water? Who is actively involved, passively affected or just indirectly concerned (please add this information respectively)?
i)SRCS Volunteers Actively involved
ii) Communities Actively involved
iii) Berkad owners Actively Involved
iv) Community elders Actively involved
v) Other NGOs Indirectly concerned
vi) The Government Ministry of Water resources

Which stakeholders, other organizations, communities, groups, or individuals could additionally contribute to the project in terms of knowledge, resources, or other kinds of qualities? Think creatively, 'around the corner' and gladly draw from your experience in other projects.
The Ministry of Water resources , NADFOR, Other NGOs because they have also constructed some berkads in some communities, FAOSWALIM, the Local government political leadership i.e the Regional governor etc,

Of all these stakeholders, who are the most important ones - and why? What should we know about them that might be critical for the success of this project?
The Ministry of Water resources because i believe have a database on existing drilled boreholes in Somaliland (although the lack berkad data), The ministry of water also has the technical expertise in water resources monitoring. NADFOR because they have a similar ongoing programme on community level monitoring of livestock body condition, market prices as well as weather variables. Other NGOs because they have also constructed some berkads in some communities.

Resource availability and positive/negative constraints

This section is concerned with the context and environment of the project. To be applicable to the actual context, the design requires negative and positive constraints. In contrast to goals, constraints define stricter limits that need to be respected in order to improve the chances of success. For example, a constraint can define what is not possible (negative constraint), as well as what essential functions need to be met (positive constraint) and what would simply be an added value.

Please list all negative constraints you can think of regarding this project. These can be the classic areas of human resources, knowledge and financial capacities as well as softer social requirements and constraints.
The project might create huge expectations from the communities as there is the ongoing drought. Whenever there is monitoring of resources communities believe this should be followed up by instant aid. Private berkad owners might not be willing to contribute to the project. They might bar Volunteers from accessing their berkads thus creating tension between community volunteers and berkad owners.

Now, please list all positive constraints you can think of regarding this project.

Are there any other requirements and/or restrictions that we need to consider when designing this project right from the beginning? These could include, for example, content, format, time management or cultural specifics.
i)There is an ongoing drought and thus the SRCS staff and volunteers might be over stretched in drought response activities.
ii) Community elders should be engaged before the start of the mapping and monitoring as they will help dispel misconceptions about the project
iii) the ministry of water resources should be in the loop during the entire project duration

Final remarks

Here you can write anything that you find important but was not addressed above. You can give feedback to the questions, raise concerns about some other issues or highlight certain aspects or perspectives.
Final remarks
All the best in your studies!

B.2 Questions & Transcript I2

Interviewer: Bosse Sottmann
Medium: Zoom
Interviewee (I): NRC CBS Somalia Manager
Date: 02.02.2023

Interviewer: Mal gucken ob ich das alles beantworten kann. Ansonsten weiß ich vielleicht jemanden, der es könnte.

I: Ich kann jetzt ja mal vorstellen was ich so im Kopf habe, was so die größeren Fragen sind. Und zwar einmal - was auch vielleicht auch Ihr Background ist. Wie das NRC auch involviert war überhaupt in den ganzen Prozess, wie es da so rum ging. Wie das angefangen hat, also die Zusammenarbeit mit dem SRCS. Was damals die Probleme, als auch das Goal war, also nicht die Probleme in der Umsetzung sondern was war eigentlich die Fragestellung, was war eigentlich das Ziel dessen. Warum genau Crowdsensing, warum haben Sie genau die Methode gewählt und keine andere? Und welche Alternativen gab es vielleicht auch? Das wäre so eine größere Frage. Eimal vielleicht einen überblick zu geben wäre für mich sehr hilfreich über die Designphase - also wie haben Sie das so organisiert auch mit dem SRCS und welche Stakeholder waren dabei? Wie wurde mit den Volunteers umgegangen, wie wurde das gehandhabt? Wie kam die Communities mit ins Spiel? Wie haben Sie das zum beispiel auch mit den Elders in der Community kommuniziert? Wie lief das so? Ich sage nur, das sind Themen, die mich gerade interessieren. Ich weiß, in einer halben Stunde kriegen wir die nicht alle durch. Wie ginge es dann vielleicht auch über in die Implementation und in die Operational Phase von diesem gesamten Projekt. Gab es bisher schon eine Evaluation? Wie läuft das so nebenbei? Und wie könnte das vielleicht denn in Zukunft aussehen? Und entweder so am Ende oder eben auch währenddessen - wie könnte man das jetzt gut auf das kommende Projekt umlegen? - natürlich potentiell kommendes Projekt. Das ist natürlich nicht in Stein gemeißelt. Aber was könnte man da als Key Take Aways mitnehmen? Wo man jetzt von Anfang an achtet, dann haben wir schon viel gewonnen

Interviewer: Ok. Also mal gucken was ich behalten habe. Also vielleicht noch kurz : Ich habe beim Norwegischen Roten Kreuz erst vor zweieinhalb Jahren angefangen. Tatsächlich - und war in der Anfangsphase von der Entwicklung der Plattform um die es ja, glaube ich ja, vorrangig geht, gar nicht dabei. Ich habe ein bischen Brackground Informationen wo es her kommt oder ich weiß warum sie entwickelt wurde. Wie ungefähr sie entwickelt wurde, aber so die spezifischen Sachen weiß ich nicht, ob ich so viel dazu beitragen kann. Also die NYSS Plattform so wie sie jetzt ist, die entwickelt sich permanent weiter. Als ich angefangen habe war sie viel oder um einiges weniger komplex. Und eines der Ziele dieser Plattform war es auch ein einfaches Data collection tool bereitzustellen. Für die National Societies. Es sollte nie, die Idee war nie es weiter zu entwickeln, weiter zu entwickeln, weiter zu entwickeln. Die Idee war, dass wie es bisher gemacht wurde, und IFRC hat bis vor Kurzem Kobo benutzt zum Beispiel und es gab diverse Formen vor wie NYSS jetzt ist. Die waren ähnlich aber, genau, waren in einem früheren Stadium und auf Basis dessen wo man gesehen hat was fehlt. Und zum Beispiel mit SRCS I3 sehr viel zusammen gesessen wurde und diskutiert wurde und was wäre jetzt nötig. Also zum Beispiel diese Feedbackmessages kommt, dieses Feature kommt aus Diskussionen mit SRCS. Also es gab, jetzt weiß ich gar nicht wie viel während der ersten Präsentation gesagt habe dazu - also da gab es ja 2017 ein riesigen Choleraausbruch in Somaliland - da ist das quasi geboren zumindest für Somaliland CBS zu machen. Ich habe vorher bei ärzte ohne Grenzen gearbeitet. Da, genau, ist das jetzt ja nichts Neues. Das machen viele schon. Es entwickelt sich halt immer, immer weiter und jetzt ist es viel populärer auch durch Covid deswegen hat das Ganze auch viel mehr, ja Popularität bekommen. Also die Plattform, wie sie jetzt so ist, ist 2019 als das war, ne, als ich angefangen habe ging das erst los, kurz vorher. 2020 das erste Mal im März überhaupt so in der Form benutzt worden. Und hinsichtlich der Entwicklung wurde zusammen diskutiert mit IFRC, den National Societies speziell SRCS, welche Bedürfnisse sie haben, was macht Sinn, was nicht. Und dann gab es so Codeons [Hackathons], in unterschiedlichen Orten. Einer war im Senegal, einer war in Norwegen, einer war in Budapest. Wo quasi Volunteers, also Softwareentwickler diese Plattform mitentwickelt haben. Jetzt ist es so, dass wir zwei Softwareentwickler in Oslo haben, die speziell, ja, daran arbeiten. Es gab letztens noch Mal eine ähnliche Veranstaltung, aber so ein großes Projekt jetzt nicht mehr - genau. Und die Idee, von dieser Plattform, ist nicht, das habe ich glaube ich beim letzten Mal schon gesagt. Das Ziel dieser Plattform ist Early Warning. Nicht 'wir sammeln jetzt Daten zu allem möglichen'. Also wir haben immer wieder Diskussionen, wo wir andere Community health Aktivitäten haben und die würden gerne NYSS benutzen um Daten zu sammeln. Zum Beispiel SGBV, die hatten gefragt, ob sie nicht mit NYSS die Healthcare Worker informieren könnten ob da nicht in der Community Opfer von SGBV [Sexual and Gender-Based Violence] oder [...] von SGBV war. Aber das machen wir nicht. Also ne wir geben ja zum Beispiel wir - Warum es auch nicht für andere case management Sachen benutzt werden kann weil keine Individuellen Daten zum Beispiel in dieser Plattform sein sollen. Dafür ist sie einfach nicht gemacht. Die Communities, also hinsichtlich Erfahrung mit den Communities. Also gut ist nicht nur in Somaliland der Fall, aber ich weiß, dass es da am Anfang auch Problem war, dass jemand von der Community 'ne Report über die, über jemanden über ein Community member schickt. SRCS investiert sehr sehr viel in Kommunikation, in Feedback vice versa mit der Community. Die treffen die regelmäßig, hören sich an was die, wie die das alles so finden, welche Bedarfe sie haben. Wir haben auch eine große Evaluierung gemacht für CBS, nicht NYSS, wir haben auch eine Evaluierung zu NYSS an sich gemacht, die wird hoffentlich bald veröffentlicht. Wo wir auch geguckt haben welche anderen Instrumente, oder welche andere Reporting Tools gibt es von anderen organisationen. Wo sind wir besser oder anders. Was sind die Vorteile und Nachteile weil die Idee - also das Problem, was ich oft habe ist - ich geh in ein Land und wir wollen CBS machen und dann ist da aber schon ein anderes, 'ne ähnliche Software oder reporting Tool. Und dann muss ich wissen, welche sind das? Wie funkionieren die? Macht es Sinn trotzdem noch advocacy für NYSS zu tun. Genau, also wir haben beides getan. CBS evaluiert für SRCS und auch die NYSS Plattform mehr global. Aber vielleicht noch eine Geschichte, die immer wieder ein Problem ist, wenn wir die Plattform einführen wollen ist die Akzeptanz und das Verständnis von MoH, also Ministry of Health. Weil die finden das oft nicht gut, dass wir, weil es kommen ja alle möglichen Organisationen ständig mit ihren eigenen Instrumenten, Methoden und was weiß ich und das finden die oft nicht so gut plus (ahhh), ich weiß auch nicht warum, also jetzt machen wir es nicht mehr so, hängen es nicht mehr so hoch auf, aber der Server von NYSS ist ja nicht im Land, ne? Der ist in Irland für Data Protection Reasons und weil es auch einfacher ist für die Softwareentwickler, ja sich darum zu kümmern. Aber das gefällt dem Ministries of Health nicht. Gerade in Ländern, die ein bischen [lach], o.k. Länder, die paranoid sind kann man so nicht sagen, aber es gibt Länder, die Panik haben, dass Dinge publik werden, die nicht publik werden sollen. Und wenn man, es gibt in vielen Ländern - zum Beispiel erklärt man ungern einen Choleraausbruch, richtig? Die wollen also die Daten in ihren eigenen Händen haben. Das niemand wie unser HQ in Oslo da Zugriff drauf hat UND SIE NICHT. Also die haben ja Zugriff auf die Plattform, aber nur zu einem Teil. Die Daten, die Ownership von den Daten ist aber mit der National Society und das finden die oft nicth so gut plus das Nächste, nicht Problem, und zum Teil haben wir das jetzt auch gelöst. Man hat Daten von den Gesundheitseinrichtungen, so Disease Sruveillance und dann haben wir die Community Based Surveillance [CBS], die unterschiedlich sind. Aber die Idee ist, sie zusammen zu bringen und da haben wir jetzt zumindest, ich weiß nicht ob dir [...] ein Begriff ist, aber das ist ja ein Datacollection Tool, was in vielen gerade afrikanischen Ländern beim Ministry of Health genutzt wird. Um auf der gesundheitseinrichtungsebene Daten von Patienten zu sammeln um auch Trends in Erkrankungen und sowas zu analysieren. Und Case management kann man damit glaube ich auch und jetzt vor Kruzem, ja haben wir es hingekriegt die Daten von der NYSS Plattform dann automatisch dann in dieses DHIS2 [?] District Health Information System reinzuschieben. genau, ja, also das als kurze Zusammenfassung. Jetzt weiß ich nicht wo ich vielleicht noch ein wenig mehr erzählen sollte.

Interviewer: Ich glaube, dass es auch noch ein paar Fragen gibt, die wert sind, gestellt zu werden, aber ein Punkt wäre für mich noch, der Stakeholder Ministry of Health, kann jetzt bei Ihnen mit rein, das wäre ja das Pendant bei uns, das Water Ministry, also das Ministry for Water Resources. Gab es denn sonst in der Community noch oder von den Volunteers oder anderen Stakeholder, mit denen Sie teilweise auch Ziele hatten, die zusammen lagen oder auch Ziele, die sich vielleicht auch ein bisschen entgegengesetzt haben? Also gab es da auch Widerstände oder gab es da noch andere Personen oder Bereiche, Rollen?

I: Von der Community?

Interviewer: Von der Community als auch von subnationaler Ebene oder von regionaler Ebene oder eben auch wirklich vom lokalen Volunteer?

I: Ja also Minister of Health definitiv, die haben sehr viele Diskussionen geführt, die führen die auch jetzt noch. Gut in anderen Ländern zum Beispiel haben wir Minister of Agriculture noch mit dabei, weil da auch Erkrankungen von Tieren zum Teil mit berichten. Mit den Communities war es am Anfang, ich glaube nicht unbedingt nur mit der Plattform an sich verbunden, sondern halt mit diesem Reporting, dass sie das am Anfang nicht verstanden haben, wo geht das hin, warum informiert ihr Minister of Health über jemanden der hier krank ist. Aber es gab dann halt viele Sessions, mit denen wo man erklärt hat warum, weshalb, wieso. Das Vertrauen in Minister of Health ist nicht so groß, das kam bei der Evaluation auch raus, aber die merken das was passiert durch SRCS, wenn mit CBS an sich. So fährt also wenn das Programm durchs Deutsche Rote Kreuz gestartet wird, also definitiv werden da ein paar Veranstaltungen mit den Community Leaders stattfinden um zu erklären was wird gemacht, wer macht was, was passiert wenn wir da, und das halt kontinuierlich also wie gesagt, die gehen da einmal im Monat oder einmal im Quartal und sitzen mit den Community Leader zusammen aber für die Details zu dem Thema ist tatsächlich I3 der Richtige, weil der ist von Anfang an dabei, der ist permanent im Projekt draußen und ist da am besten auch wahrscheinlich kann der da auch gut beraten wer am besten, mit wem am besten für das Thema zu sprechen ist.

Interviewer: Ja, I1 hatte das schon einiges angesprochen, aber das ist mit Sicherheit nochmal sehr sehr gut, die stehen bestimmt auch mit einem anderen in Kontakt

I: Ja, also I3 die, genau, er hat mir erzählt, dass er mit I3 gesprochen hatte und dann I3 das an mich weitergeleitet hatte, obwohl er also gerade für solche Fragen definitiv der richtige Ansprechpartner ist.

Interviewer: Und was gibt es denn noch für andere Methoden, die noch genutzt werden neben diesem Crowdsensing und dem Volunteer-Sensing in anderen Regionen?

I: Kobo, oder einfach in Kobo haben sie zum Beispiel in Uganda genutzt oder in Bukina Faso haben wir jetzt einfach Excel-Sheets also die Volunteers statt von diesen Plattformen eine SMS zu schicken, schicken die gleiche SMS an ihren Supervisor und der trägt das dann in Excel ein, weil das Ministry of Health wollte nicht, dass wir nicht, dass wir NYSS benutzen. Und dann waren wir es halt ein bisschen umständlicher, aber am Ende eigentlich das Gleiche Aber dieses, die wollten halt keinen, die haben eine Organisation, die ein Community-Health-Programm einführt, ich glaube die Zahlen halt ans Ministry of Health. Das tun wir nicht. Und dann haben sie sich für dieses Programm entschieden, auch wenn es nicht das Gleiche tut, was nichts macht, aber das verstehen die Leute halt nicht immer. Genau, also wahrscheinlich auch die Arbeit mit den Ministries, vielleicht kann man da, aber da ist vielleicht I3, auch der richtige Ansprechpartner möglicherweise macht es auch Sinn, da jemanden vom Minister of Health mit hinzunehmen oder dass man sich austauscht mit dem vom Minister of Health, um die Benefits auch zu zeigen damit man da nicht wieder von vorne anfängt und die die gleiche Skepsis haben, sondern wenn die sehen, das gleiche Tool ist schon vom Minister of Health benutzt und erfolgreich benutzt die wollen das landesweit einführen und wir sind kurz davor, ist es natürlich leichter auch möglicherweise die anderen Departments der Regierung zu überzeugen

Interviewer: Ja, noch mal kurz ein Stück zurück, [...], wir hatten ja auch schon über das gesprochen, noch mal ein bisschen tickentechnischer, aber doch noch im Management bleiben, dass man das von der Analogenwelt in das Digitale reinbekommt und dafür, dass man dann natürlich auch Kategorien braucht, zusammen mit diesem [...] Data Collection Platform, wie ist da so die Stimmung oder der Gedanke bezüglich eben auch der Erhebung und dem Monitoring von Water Resources weil wenn ich jetzt sage, Water Availability hat natürlich jetzt okay, wie viel Wasser ist da, aber es gibt natürlich auf der anderen Seite auch welche Qualität hat es wie viel kommt nach, wer hat überhaupt Access dazu, es gibt einige Berkads oder sogar mehrere, die dann natürlich auch privat gehandhabt werden und wo nicht jeder Access zu hat. Da müsste man tatsächlich eine ganze Menge Daten durchaus erheben und auch durchaus so gestalten, dass sie flexibel veränderbar sind, weil wenn jetzt zum Beispiel ein Dorf oder ein Hirte kommt mit 200 Tieren, dann ist es natürlich eine hohe Wasserabgabe. Dann wäre es doch auch natürlich zum Sinne des Forecastings aber auch wieder Datenerhebung, insofern, wie passt das auch dazu?

I: Also es ist kein Forecasting Tool, es ist ein Early Warning Tool, deswegen habe ich beim letzten Mal auch darauf gepocht und ich hatte es so verstanden, dass es eher Early Warning, Early Action benutzt wird. Die Wahrscheinlichkeit, dass wir das Rote Kreuz sich darauf einlässt, das weiterzuentwickeln, zu dem Zweck, sehe ich nicht, das kann ich jetzt schon sagen. Wenn es wirklich eine einfache Geschichte ist, die man einfach machen kann, wo es einfach nur geht, eine SMS zu schicken, wo es darum geht, hier ist kein Wasser mehr, ist das eine andere Geschichte, als wenn es eine große Data Collection, also die werden kein, das weiß ich jetzt schon, das wird nichts. Deswegen hatte ich beim letzten Mal noch gefragt, was wird wirklich wozu und was ist an Daten nötig? Das wäre okay, wenn es darüber hinausgeht. Das glaube ich nicht.

Interviewer: Genau, deswegen frage ich nach, das Ziel ist ja an sich, einen Trigger zu definieren, dass der dem dortigen somalischen Ruten Kreuz dann die Ermittlung gibt, wir haben langsam kein Wasser mehr und wir brauchen jetzt demnächst eine Lösung. Das ist ja an sich das Ziel, das heißt, wenn wir wissen, okay, das kriegen wir nicht in die Plattform rein, dann kann man ja auch den anderen Schritt machen, okay, dann muss der Volunteer besser geschult werden, weil dann muss der Volunteer das selber überblicken können. Dann können wir das halt nicht in der Plattform errechnen, sondern dann brauchen wir, das wäre auch die nächste Frage, wie kann man auf dieses lokale Wissen vertrauen, wie kann man das gut einbinden vielleicht auch, wir wissen ja auch.

I: Okay, nochmal zurück zu den vorherigen, also was der Volunteer schicken würde, wäre ja regelmäßige wöchentliche Updates, ist es voll, halb voll oder leer. Es gibt noch die Möglichkeit, dass dann jemand, der die Plattform händelt, und das sind dann ja nicht die Volunteers, wenn man anruft, also was passiert bei dem, was wir machen, ist ja immer noch der Supervisor, der das validiert. Die rufen da an, sind es wirklich die Symptome, die die gerade berichtet haben. Und erst dann gibt der Klick, okay, das ist wirklich ein True-Alert. Und dann hat der Supervisor noch die Möglichkeit, wenn wir zum Beispiel, die Idee dann ist ja, es geht ans Ministery of Health und dann soll der Supervisor und Volunteer gucken, dass da Investigation Response vom, möglichst vom Minister of Health passiert. Und dann können die in so einem Event-Blog noch Notizen machen zu diesem Alert. Also, was man tun, was man überlegen könnte, wenn jetzt noch irgendwelche extra Informationen zu dieser Information, okay, es ist leer oder voll, wenn es noch irgendwelche anderen Informationen nötig wären, könnte der Supervisor am Telefon das checken und immernoch noch eintragen, richtig? Also, ich kann das auch vielleicht noch mal zeigen in der Demonstration.

Interviewer: Ich habe mir die Demonstration angeschaut. Ich habe mich da ein bisschen mehr angelesen.

I: Okay, gut, also da gibt es diesen Event-Blog, der wäre eine Möglichkeit, wenn man noch mehr Informationen zu diesem Alert haben möchte. Hinsicht, ob man den Daten trauen kann, also, das kommt jetzt so ein bisschen drauf an, weil die Themen sind ja schon ein bisschen anders. In unserem Fall berichten sie ja von jemandem, der krank ist mit bestimmten Symptomen oder mehrere, die das gleiche haben oder Tiere. In dem Fall wäre da jetzt kein, okay, der Benefit wäre, da passiert was, richtig? Die Ministry of Health kommt, macht Vaccination Campaign, Chlorination Activities, bla, bla. In dem Fall jetzt mit dem Wasser, gut, wenn die Volunteers, also, was ein großer success Faktor für dieses Projekt, CBS-Projekt mit SRCS ist, ist Supervision, das Refresher Training, Supervision, dass die Supervisor geben, glaube ich, mindestens einmal im Monat, zumindest in der Vergangenheit. Jetzt werden die, die brauchen das nicht mehr monatlich, weil wir haben jetzt Evaluation gemacht, wir sehen es in den Daten, die wissen, was sie tun. Die kennen ihr Business. Das wird in dem Projekt am Anfang mehr intensiv sein, dass die Supervisor da häufiger hinmüssen, checken müssen, haben sie das jetzt wirklich richtig eingeschätzt. Und wenn die nach einer Weile sehen, dass die oft falsch, falsche Reports senden, also immer sagt, es ist leer, es ist leer, in der Hoffnung, sie kriegen vielleicht mehr Wasser in dieser Community, dann muss man sich halt was einfallen lassen. Also das ist jetzt was, was mich spontan einfällt, was sein könnte, einfach die Hoffnung, es ist zwar voll, aber ich sage jetzt trotzdem, es ist nur halb voll, weil dann kommt jemand und gibt uns mehr Wasser, gerade mit den Droughts der vergangenen Zeit, das könnte sein, aber dann muss man einfach mit den Volunteers arbeiten und denen quasi auch klar machen, was passiert wann und wir checken das. Was man auch machen kann und das ist weniger sensitiv als bei uns, Fotos schicken, wenn die Smartphones haben. Das ist nicht immer der Fall, aber in manchen Projekten werden Fotos von Symptomen, zum Beispiel von der Haut oder so geschickt. In dem Fall jetzt mit diesen Wasserspeichern könnte man einfach, wenn man denn Smartphones verteilen möchte, ich bin kein Fan davon, aus unterschiedlichen Gründen, aber wenn das Teil der Geschichte ist, dann kann man die auch fragen, ob sie nicht ein Foto schickt, zusammen mit dem Report, um das nochmal zu validieren, wenn man nicht da vorbeifahren will. Aber in den Trainings zeigt man denen halt, okay, ab wann ist es voll, ab wann ist es halb voll, wie soll es aussehen und dann kann man erst so ein bisschen durch supervision und feedback kontrollieren. Und wenn der Volunteer immer, also irgendwann merken sie auch, das macht keinen Sinn, der kommt keine und bringt mir extra Wasser. Dann hat es so erledigt, das will ich jetzt mal. Aber gut, man weiß nie, was am Ende, wirklich da eine Community ist passiert.

Interviewer: Ja, wie ist das denn, wenn man da ist, wenn man jetzt da reingeht, haben die dann sofort auch irgendwie die Expectations, dass sie auch Hilfe bekommen?

I: Ja.

Interviewer: Weil es kann ja auch sein, okay, in dieses Risiko mit Wasser geht ja auch noch mehr rein, also vielleicht kann die Community sich auch selber helfen oder man sagt, okay, die haben halt nur so viel, wie ist da also die Erfahrung, vielleicht bei dem Haupt, von dem Projekt, vielleicht auch von anderen Projekten, wie kann man damit umgehen, von Anfang an im Design-Prozess?

I: Okay, jetzt war es ein bisschen weg. Okay, aber ich glaube, ich habe es verstanden. Also, was wir, wenn wir mit Ministery of Health zusammenarbeiten oder überhaupt uns dafür entscheiden, ob wir CBS machen oder nicht, es muss sicher sein, da ist, es passiert was, nachdem dieser Report geschickt wurde. Und das erste, was passiert, ist, dass die Volunteers, die sind ja geschult in First Aid und Health Promotion, die können schon mal ein bisschen was tun. Also die Community, es ist nicht so, ach, ich bin krank und nichts passiert. Also die Volunteers tun was. Wir haben die Mobile Clinics von SRCS, die manchmal die sind die antworten, aber das funktioniert inzwischen ganz gut aber mit logistischer Hilfe oder finanzieller Hilfe kommt auch Minister of Healthy. Genau, also was klar sein muss ist, es geht nicht nur darum, einen Report zu senden und da ist ein Bedarf und nichts passiert. Also was klar sein muss von Anfang an, ist, was passiert wann, wann erwarten wir und das muss man mit den Communities auch klar machen, wann, in welcher Situation erwarten wir von euch, dass ihr euch selbst helft. Aber das wird ja sicherlich vorher definiert, wann müssen wir wirklich mit einem Truck kommen und diesen Speicher auffüllen oder wann sollten die noch warten oder was weiß ich. Also das auf jeden Fall mit denen besprechen und klar machen, sonst stehen die da und am Ende sind es die Volunteers, die die Probleme haben. Und es fällt negativ auf SRCS zurück.

Interviewer: Aber das Netzwerk ist groß genug auch von den Supervisoren, dass es nicht komplett automatisiert sein muss. Man kann schon davon ausgehen, da sagen wir, sie melden jetzt es ist halb voll, dann halb leer, dass der Supervisor da anrufen kann und sagen kann, okay, unsere Kapazitäten sind an der Grenze.

I: Okay, es bricht zu sehr. Ich habe einen Teil jetzt gar nicht verstanden. Also irgendwas mit Netzwerk von Supervisoren habe ich noch was verstanden. Ist das? Ja, jetzt ist besser.

Interviewer: Okay, wir versuchen mal näher ran. Ja. Ist es möglich, darüber zu gehen, dass man sagt, okay, nachher, wenn man sagt, es ist nur noch halb voll, der Supervisor sagt dann, okay, uns fehlen die Kapazitäten, euch was zu liefern gerade. Anderen Communities geht es noch schlimmer. Ihr müsst besser rationieren. Wie ist die Erfahrung da? Ist das kleinteilig genug, dass das nicht automatisiert sein muss, diese Feedback-Messages?

I: Also ich glaube, das kann man am Telefon besprechen. Ich würde nur vorher den Community sagen, dass es Situationen geben kann aufgrund von A, B, C, D, dass wir eben nicht in der Lage sein werden, das sofort zu füllen, dass es länger dauern kann. Und wir euch dann bitten zu rationalisieren. Dann kann man mit denen besprechen, wo sie glauben, dass man dann vielleicht rationalisieren könnte. Vielleicht kann man denen auch versuchen, ein Timeframe zu geben, wie lange man bräuchte, damit die das selber einschätzen können. Aber, ja. Genau. Also falls das der Fall sein sollte, dass der Fall eintritt, das muss man vorher besprechen und das ankündigen, dass es passieren kann, weil dann verliert man zumindest nicht das Vertrauen. Wenn man jetzt schon antizipieren kann, da ist das Risiko, und du weißt es, Contingency Plan, at Community Level, dann zusammen mit denen werden sich vielleicht auch meckern und beklagen, aber dann weiß man zumindest, was passieren kann. Dann ist der Schaden wahrscheinlich geringer für das Image von allen Beteiligten. Ja.

Interviewer: Okay, wir sind jetzt schon über die halbe Stunde.

I: Ja, ich weiß nicht, was ich noch sagen kann.

Interviewer: Vielleicht einmal noch eine qualitative Eingliederung, dessen wir darüber auch gesprochen haben. Was waren so die Key Points, die Key Lessons learned, aber auch die Probleme, wo man sagt, da könnten wir jetzt drauf achten. Was sehen Sie als kritischste Punkte an? Oder wo sagen Sie, okay, da sollte man jetzt von Anfang an sehr genau drauf achten? Und welche Herausforderungen sind gekommen? Was könnte der Fokus sein, was sollte im Fokus stehen durch die Erfahrung?

I: Um so ein Programm einzuführen, nicht NYSS an sich, aber CBS an sich ja?

Interviewer: CBS und genau an sich, aber jetzt vielleicht auch in speziellerer Bezug auf das Water Early Action, Anticipatory Action, Water Monitoring. Natürlich herauskommt aus dem eingeführten CBS.

I: Also, so ein paar Keys für die Implementierung oder Planung von CBS. Also, keine Ahnung, ich werde es jetzt einfach rein und manche sind vielleicht schon auf dem Schirm und andere nicht. Also, wir machen ja immer, bevor wir CBS tun, ein Assessment richtig? Im Land auf Nationellebene, auf Projektebene, um zu gucken, gibt es da schon was. Weil ich habe das ja schon zweimal gehabt im Süd-Sudan, in Nigeria, eigentlich gibt es da schon CBS. Dann muss man gucken, welche gap es dann gäbe und wie kann die National Society das füllen. Das ist eins. Und dann treffen wir Minister of Health und erklären, manchmal, also oft treffe ich die vorher schon, und erkläre, was wir tun, was wir dieses Assessment tun und man muss sowieso Interviews mit denen führen. Insofern kann man das gut kombinieren, um schon herauszufinden, was eigentlich, also in dem Wasserprogramm wäre es dann irgendwie diese andere Department. Und dann spiegeln wir die Ergebnisse zurück an Ministery of Health und dann zusammen entscheiden wir halt, was machen wir, so machen wir es, wie machen wir es. Und dann versuchen wir natürlich auch unsere Vorstellungen damit reinfließen zu lassen, wie zum Beispiel die Plattform zu benutzen. Oder wenn wir zum Beispiel sehen, dass bestimmte Health Risks die Ministery of Health möchte, wir aber denken, das macht keinen Sinn oder es sind zu viele. Wir machen immer, wir entwickeln die Strategie, das Protokoll für CBS immer zusammen mit Ministery of Health. Die sind mit in den TOTs (Training Of Trainers), dann Volunteers sind von der Community, die Community Leaders, suchen die aus. Hier muss man uns in unserem Fall, und ich glaube, SRCS ist generell eine Strategie, keine Incentives. Das ist tatsächlich auch nur zum Beispiel nur in Somaliland mehr oder weniger der Fall, dass die ohne Incentives arbeiten, deren Incentive ist quasi Trainings. Da kriegen wir dann immer für den Transport. Genau, also Community muss die aussuchen und I3 kann da auch noch mehr Inputs geben, weil am Anfang oder oft, gerade wenn Incentives gezahlt werden, dann natürlich die Tochter der Sohn oder wie auch immer da ausgesucht wird. Die gehen aber wirklicherweise in drei Monate studieren und dann muss man einen neuen finden. So, also oft sind es Frauen, die Volunteers sind, weil die eben in der Community bleiben und nicht wie die Männer, die mal hier mal da sind. Genau, dann, genau, regular supervision, evaluations, talking with communities, Ministery of Health. Wir haben regelmäßige Meetings, wir sind in den Meetings mit dem Minister of Health. Ja, ich glaube, das andere habe ich dann auch schon, also nicht, dass man mit den Communities am Anfang, reden muss, wenn man das Programm aufsetzt, aber ich glaube, SRCS, machen das ja, die sind ja keine Anfänger. Die machen das auf jeden Fall, also die wissen das einfach. Ich glaube, es ist einfach ein Teil der Kultur das zu tun, bevor man irgendwo reingeht mit irgendwas.

Interviewer: Gibt es das mit dem internationalen Kontext oder aus dem nationalen Kontext noch andere NGOs oder andere Player, die da irgendwie ihre Finger mit rein mit drin haben wollen oder doch noch ein bisschen querschießen?

I: Querschießen nicht, aber zum Beispiel, also versuchen wir mit der WHO also mit der Weltgesundheitsorganisation, die sind ja in allen Ländern, mit denen auch zusammenzuarbeiten, die sind interessiert daran, was wir tun. Es gibt CDC, Center for Disease Control, die gibt es in, aber die gehören meistens zum Ministery of Health. Das Problem mit anderen Organisationen, okay, querschießen tun die nicht, aber also das Problem, was wir zum Beispiel im Südsudan hatten, da wo wir hin wollten, da war schon eine andere Organisation, die Community Health gemacht hat und CBS, aber nur zum Teil. Die Communities haben sich aber zum Beispiel beschwert, dass die das eigentlich gar nicht tun oder nicht genug und die Qualität nicht gut ist und die wollten, dass das Rote Kreuz mehr macht. Aber am Ende kann man da, und das Bekloppte war auch das Ministery of Health einfach keine Ahnung hatte, wer was gemacht hat, weil die hätten von Anfang an sagen müssen, nee, da haben wir schon jemand. Wir haben ein großes Assessment gemacht und am Ende habe ich mit diesen Organisationen zusammensetzt und dann erzählen die uns, dass die da quasi diesen Plan haben oder bereits angefangen haben, dass ähnliche Sachen zu implementieren und selbst wenn die Qualität schlecht ist, kann man da nicht einfach das gleiche machen. Das glaube ich aber jetzt nicht, in Somaliland, dass da so viele andere sind, die das gleiche machen. CBS definitiv nicht, da ist niemand anders. Ich weiß nicht, ob MSF da irgendwo ist, aber ja, in Somalia, glaube ich nicht. Ah ne, die sind auch in Somalia. Aber genau, da kann man ja, und normalerweise sollte das das Ministry wissen, wer da was macht und wenn nicht die, dann spätestens die Communitys. Genau, also man muss einfach gucken, wenn man das Assessment macht, sind da andere irgendwo, es kann ja, muss ja nicht unbedingt in den Projektlocations sein, woanders, von denen man auch lernen kann. Also es ist eher diese Competition-Geschichte, als, und da muss man halt viele Organisationen, die haben halt das Geld für diese Region bekommen, dann müssen die da hin, ne, und dann wird es aber einfach, ja, ein bisschen blöd. Aber generell so, gegen CBS, alle wollen CBS machen. Alle wissen, dass es gut ist.

I: Ja, also ich finde es ziemlich erstaunlich, weil ich habe jetzt in der wissenschaftlichen Literatur sehr wenig gefunden.

I: Es ist leider nicht viel veröffentlicht und ich versuche seit zwei Jahren, einen Artikel zu schreiben. über CBS an sich.

Interviewer: Also CBS, ja, also es gab jetzt von 2021, meine ich, noch ein Paper, die jetzt gerade auch für Broad sehr dafür advokiert haben, mehrere Sachen mal aufzunehmen, was aber so ein bisschen mehr in Data Collection eingeht. Dass man halt sagt, okay, wir regieren jetzt nicht mehr darüber mit Satellitendaten und großen nationalen, übernationalen Datensätzen, die wir erheben, sondern wir wollen halt vor allem auch ein Impact Assessment machen von Drought. Haben durchaus ein, zwei sehr aufwendige Questionnaires entwickelt, nicht unbedingt komplizierte, aber durchaus aufwendig, die dann auch in diese longitudinal studies mit reinpassen von WHO. Also da gibt es mehr oder minder auch eher einen Call für diese Paper.

I: Ja, genau, also von Conlfict and Health habe ich schon seit zwei Jahren Call for Papers, um was über CBS zu veröffentlichen. Ich habe diverse Papers. Ich weiß nicht, ob das genau, das ist, also ist mehr health related. Ich kann die, kann die schicken, wo ein bisschen, ja, zumindest was publiziert wurde über CBS, wie es implementiert ist mit den Outcomes. Aber genau, wir haben es. Ich brauche nur Zeit, um ganz genau zu sagen, was wir hier im Lande sind. Ja, das kann ich noch schicken. Genau, noch mal, was halt oft der Fall ist, aber ich glaube, in Somaliland ist das nicht das Problem. Es gibt Länder, wo die Regierung einfach sagt, weil oft das Label CBS Surveillance hat eine negative Implikation. Zum Beispiel in Pakistan können wir CBS so nicht verwenden. Wir sagen halt, wir berichten von Kranken aus der Community. Weil Surveillance, da gehen die Alarmglocken an, dass man da irgendwo ausspioniert oder so. Also das, aber dadurch, dass Somaliland jetzt zumindest im Gesundheitsministerium inzwischen einfach viele Jahre Erfahrung und gute Erfahrung hat nit CBS, sollte man die nutzen. Ja, um das auszuweiten auf andere Themen.

Interviewer: Okay, dann hätte ich da auch nur noch eine Frage oder vielleicht eine Bitte. Also nach einer Einschätzung von der generellen Impression über das gesamte Projekt, jetzt vielleicht CBS als auch dieses, diesen Ausblick, sag ich mal, auf ein mögliches Wasserquellen-Monitoring und vielleicht auch noch eine Frage, gibt es von Ihrer Seite irgendwie Wünsche oder so, dass die gerne irgendwie so aus der Erfahrung mit reinfließen sollten?

I: Also wir machen ja alles jetzt basierend auf Erfahrung der letzten Jahre und Projekte. Und die fließen dann immer direkt und die sind jetzt auch an die, das was ich gerade erzählt habe, eingeflossen. Also warum ich glaube und versuche, dass nächste Woche, wenn ich mit denen spreche, da vielleicht doch zu veranknern kann, es sei denn, genau, die Bedarfe sind größer als das, was ich jetzt verstanden habe. Also diese Wassersourcegeschichten, deshalb es würde halt thematisch gut passend, weil es ein Health Risk ist, um auch Tiergesundheit, Menschgesundheit negativ zu beeinflussen und Outbreaks zu, wie sagt man, also quasi die Basis zu bereiten für Outbreaks, ob es jetzt beim Tier oder beim Mensch ist. Insofern würde das thematisch eigentlich, und wir haben ja diesen Unusual Events, wo eigentlich genau oder ähnliche Sachen ja bereits schon berücksichtigt sind. Das Spezifische hier wäre quasi, dass sie von einem bestimmten Wasserpunkt oder watersourcepunkt kommen und dann vielleicht noch Unterkategorien hat, aber ansonsten ist es, der ist jetzt nicht neu neu. Insofern finde ich, würde es gut passen, aber man weiß immer nicht, was ich vielleicht übersehen habe. Das werde ich jetzt nächste Woche herausfinden, aber bislang haben sie mir noch nicht gesagt, dass es total abwegig ist.

Interviewer: Genau, von meiner Seite ja auch, ich versuche ja gerade diesen Designprozess, dieses Projekt zu designen, und da geht es ja gerade jetzt, vor allem jetzt momentan in der Phase, deswegen hatte ich auch nachgefragt, ob wir uns jetzt schon unterhalten können, ganz klar um diese Constraints. Also wenn ich weiß, okay, alles was möglich ist, ist... Wir haben Berkad 1, 2, 3, und ich kann sagen, voll, halb leer oder leer, oder vielleicht 5 Phasen, und das ist das, was das System leisten kann, und alles andere müsste über das Telefon mit dem Supervisor geregelt werden, dann ist das ja vollkommen in Ordnung. Deswegen frage ich jetzt genau, also ich bin persönlich gar nicht festgefahren, und ich glaube auch hier, jetzt sonst keiner bei uns, dass es jetzt genau so oder so aussehen muss, sondern es soll funktionieren und es soll in den Prozess reinpassen, deswegen ist bei uns, denke ich, eine hohe Offenheit da, und gerade jetzt eben herauszufinden, in was für einem Kontext, in was für einem Rahmen arbeiten wir, was können wir machen und wie können wir es machen.

I: Ja, vielleicht noch die Idee, warum wir zum Beispiel diese Codo-Sache haben, oder auch, dass das alles mit einem normalen Telefon ist, was der Unterschied zu vielen anderen Tools ist. Ich glaube, es gibt kaum ein anderes Surveillance-Tool, was mit einem normalen Basic Phone möglich ist. Die meisten brauchen ein Smartphone, und das ist in vielen Gegenden, wo wir arbeiten, nicht möglich. Erstens kann ich nicht ständig Smartphones verteilen, oft haben wir auch gar kein Netzwerk und so weiter und die Volunteers mit denen wir arbeiten, das Kriterium für die ist nicht gut gebildet zu sein und oft bei den Tools die es gibt wo mehr Daten mehr Informationen nötig ist für Case management, zum Beispiel wo die Volunteers dann selber eintragen müssen, dann brauchst du jemand der Englisch spricht oder zumindest schreiben kann und das ist halt auch nicht der Fall. Und durch das Telefonat, wenn man mehr Informationen braucht zu einem bestimmten Report, das kann man einfach so wie bei uns auch der Supervisor einfach erledigen, der Zugang zu zur Plattform hat. Weil dies möglicherweise gar nicht, nicht eingeben können...

Interviewer: Ich hatte bei NYSS bei den Codes gesehen, dass man schon sagen kann männlich, weiblich, unter 5, über 5, sind so zwei bis drei Sachen, also durchaus zum Beispiel was Wasserqualität angeht, je weniger Wasser drin ist desto mehr Schadstoffkonzentration habe ich ja auch durchaus häufig. Kann man also das vielleicht auch noch mitnehmen pro Berkad, dass man sagt pro Berkad, kann man auch noch sagen, der ist voll und die Wasserqualität sieht gut aus, und er ist auch accessible für uns?

I: Also wir werden es noch nicht gezeigt, es ist auch möglich mit NYSS, wenn wir zum Beispiel Outbreaks haben, kann man nicht mehr zu jedem der krank ist einen Report schicken, das macht keinen Sinn, weil wir wissen, da ist ein Outbreak, jetzt geht es mehr darum zu wissen, wie viele pro Tag hast du gefunden und so weiter. Also es gibt auch die Möglichkeit mit noch mehr Codes mehr Informationen zu vermitteln. Also zum Beispiel haben wir, wenn Cholera-Ausbruch ist, werden bestimmte Volunteers, die möglicherweise, also die werden ausgewählt aufgrund wahrscheinlich auch ihres kognitiven, kognitiven Capacity, ja, die dann von diesen Oral Rehydration Coins einmal pro Tag eine länger Code schicken. Der beinhaltet dann, okay, wie viele waren heute da, wie viele waren weiblich, wie viele männlich, wie viele unter fünf, wie viele über fünf, wie viele sind da gestorben, wie viele sind von einem anderen Village gekommen, also ich glaube es sind am Ende bis zu sieben Zahlen. Wenn man den kleine Tools, also was wir am Anfang machen, die ins Somaliland, die Volunteers, die wissen das inzwischen, aber die haben auch so kleine Zettelchen, wo die Codes quasi, kann ich auch noch schicken, Codes quasi erklärt sind, was die bedeuten und wie sie sich, also sie kriegen ja Trainings, aber das kann man ja nicht alles behalten, ich auch nicht, ich muss ständig gucken, welcher Code ist jetzt was und dann kann man denen das geben, wenn die auch mehr, also was man überlegen könnte in dem Fall ist, genau der erste Code ist vielleicht, die Nummer des Water Source, dann, ob sie voll ist oder nicht, dann kann man sagen, eins, zwei, drei und dann Hasch, keine Ahnung, welche andere Kategorien möglich sind, dass man da noch zwei, drei, würde ich zu weit gehen, andere Codes, weil das schränkt dann wieder ein, wen man als Volunteer nehmen kann und dann kann man das auch schreiben, was was ist.

Interviewer: Genau, also zwei bis drei andere Codes, das war auch so das, was ich mir vorgestellt hatte und was dann ja auch schon viel helfen könnte, weil auch wenn die Wasserqualität, vielleicht viel Wasser da ist, aber sie sagen, die Wasserqualität ist schlecht, auch dann könnte man ja schon eine Early Action draus machen, dass sie sagen, okay, wir bringen irgendwie etwas um, also zum Beispiel Chlor, um eben einen Ausbruch von Krankheit, wegen schlechter Wasserqualität, in dem Fall schon.

I: Und dem wird dann erklärt, wann das Wasser schlecht ist, wie sie das einschätzen können.

Interviewer: Genau, das ist jetzt gerade ein Gedanke, der läuft parallel, aber genau das müsste natürlich alles mitlaufen und vielleicht kann man dann auch so ein kleines Zettelchen oder dann, wie muss es riechen, wie muss es schmecken, wie ist es, wenn man sagt, okay, jetzt wird es kritisch. Ich bin kein Experte im Wassermanagement. Ich glaube, das kann man mal...

I: Ich habe nicht verstanden, dass die Tiere da auch dran trinken oder nicht?

Interviewer: So wie ich das verstanden habe, gibt es davon ganz, ganz viele unterschiedliche Möglichkeiten. Also manche von diesen Berkads sind einfach nur Löcher im Boden, andere sind von NGOs gebaut mit betoniert, andere sind dann auch weiter, dass sie sagen, okay, sie haben sogar noch ein Blechdach drüber, die dann sogar noch weitergehen und sagen, okay, da verdunstet das dann und alles, was verdunstet, läuft ab in einen extra Trichter, in so ein extra Gefäß, was dann schon dadurch dann eigentlich mehr oder minder sauber ist, weil es erst mal verdunstet und dann abläuft. Also es gibt wohl sehr, sehr viele und auch das ist so ein bisschen noch eine Frage, ist der Berkad überhaupt funktional? Also das wäre auch so ein bisschen eine Early Action, wenn wirklich eine Rainy Season kommt, welcher Berkad ist überhaupt in der Lage, Wasser aufzunehmen und welcher braucht erst noch Reparaturen? Aber das wäre nochmal ein bisschen was anderes, das läuft so ein bisschen nebenher. Das Thema wird doch im Detail sehr komplex und es wird schon nochmal [...], aber ich glaube, das ist ja bei den meisten so. Das ist natürlich jetzt nichts mehr Neues.

I: Okay, nur noch ein Kommentar, falls das aus irgendwelchen Gründen nicht sein sollte, wie ich es vorher schon gesagt habe, es gibt ja diverse andere Möglichkeiten, die gehen. Also das Gute an dies ist all das automatische, richtig? Feedback messages, notifications zum Ministry, notifications zum Supervisor, automatische Maps, Graphs and so forth. Das aber wenn jetzt aus irgendeinem Grund das nicht möglich ist, dann kann man immer noch mit normaler SMS, die der Supervisor dann nachverfolgt und den Eintrag in Excel macht, dann seine eigenen automatischen, zum Beispiel das Team in Burkina Faso, die National Society, die haben super Typen, der da ganz tolle automatische Graphs in Excel kreiert, die alle ähnlich sind wie NYSS, nur dass es eben manuell eingetragen werden muss.

Interviewer: Ja, sonst ist NYSS aber ja auch Open Source, wenn ich richtig gesehen habe.

I: Ja, genau. Aber also wenn jetzt zum Beispiel, jetzt was ich meine ist, wenn jetzt zum Beispiel IFRC zum Beispiel sagt, aber wir wollen über unusual events nicht hinausgehen für solche Sachen, dann macht es keinen Sinn. Also wenn wir jetzt nicht sagen, weil in dem Fall würde das tatsächlich bedeuten, wir brauchen neuen Code für diese Geschichte und dann all die anderen Codes, also Arbeit ist da schon und die Frage wäre dann auch, okay wer zahlt die Arbeitsstunden, macht das Norwegische Rotkreuz bla bla bla, wenn da Interesse ist oder muss es vom Deutschen Rotkreuz getragen werden, die extra Stunden, die für diese Weiterentwicklung nötig sind. Genau, wenn das nicht stattfindet, dann macht es möglicherweise einfach keinen Sinn, weil das, was die Idee ist, dann einfach damit nicht möglich ist, wenn man nur sagen kann, ich habe ein unusual event, ist die Frage, ob man nicht besser, einfach eine SMS schickt zum Supervisor mit mehr Information. Aber das können wir gucken, vielleicht weiß ich Ende nächster Woche mehr.

Interviewer: Gut, dann drücke ich da mal die Daumen.

I: Ja, genau, ich auch. Gut. Dann kann I1 ja den Link mit I3 herstellen, der ist gerade in Nairobi, um für Sanlisa für Oslo zu kämpfen. Genau, dann ist er in Oslo deswegen, aber jetzt während er in Nairobi ist, hat er vielleicht auch Zeiten online.

Interviewer: Gut, vielen Dank.

I: Alles gerne. Viel Erfolg.

Interviewer: Danke schön. Falls noch irgendwie Gedanken kommen oder so, oder auch die Sachen gerne über E-Mail.

I: Die Artikel schicke ich noch.

Interviewer: Vielen Dank. Und vielleicht häufiger von anderen Tools geredet neben Kobo, falls da noch mal kurz eine ganz kurze informelle Liste, falls da irgendetwas...

I: Zu Kobo?

Interviewer: Ne, nicht unbedingt zu Kobo, aber falls es noch mal andere Ideen gibt oder noch mal wie auch immer.

I: Ja, okay, alles klar. Ja, aber wahrscheinlich wäre Kobo dann schon eher die bessere Lösung, falls es mit NYSS nicht klappt.

Interviewer: Okay, vielen Dank.

I: Okay, viel Erfolg.

Interviewer: Danke schön.

I: Tschüss.

Interviewer: Tschüss.

I: Ciao, ciao.

B.3 Questionnaire & Answers I1.2

Interviewer: Bosse Sottmann
Medium: Google Forms
Interviewee: GRC FbF Manager of the SRCS
Date: 28.02.2023

Introduction

Hello and As-salamu alaykum,
thank you for taking time to give some insights to your experiences!
My name is Bosse Sottmann, and I am currently studying at the Heidelberg University and am enrolled in the Master's programme in Geography. In the context of this programme, I am currently working on my thesis in the HeiGIT team that is involved in the development of the Early Action Protocol.
The overall goal of this project is the development of a mapping and monitoring approach on community level primarily for the water source type of Berkads to ultimately enable triggering action before critical water levels. Sub-goals are based on the learnings which water levels trigger which actions, what information needs to be known about the source initially, continuously and what other information would be helpful in the context of Anticipatory Actions.
The work will be based on a variety of different sources of information. In addition to this questionnaire and others, best practices and knowledge will be gathered from the literature. Therefore, your input to this questionnaire is critical in learning more from the local perspective in order to not only transfer experiences and learnings to the new design but make this applicable to the local circumstances as best as possible. Your and the SRCSs opinions, experiences and needs will be the foundation of the work – ensuring that the resulting design meets your requirements.
The questions are structured in multiple stages and each question will be open-ended. Thus, feel free to add more information where ever you want or think necessary. Additionally, at the end of the questionnaire, further remarks can be made.
Nonetheless, a disclaimer should be made, that this is a project in the context of a Master's thesis, thus a fully-fledged design ready to get launched is out of scope of this work. Yet, it can lay a good foundation for the following work.
All answers will be confidential and you can skip any questions you are not comfortable with.
Thank you very much for your time and energy!

General Questions

Please give a short introduction to yourself, your role, experiences and work. *I1. Im the GRC Forecast based Financing delegate based in Hargeisa, Somaliland. I am supporting the SRCS to undertake the Forecast based Financing project. The project aims to develop Anticipatory Actions that will counter forecastable hazards such as drought, flooding, cyclones and epidemics.*

Local context

Please tell me about the current conditions on site to gain a better understanding of the local circumstances by walking me through the process of how anticipatory actions/response in regard to water availability/shortage currently work on community level.
Due to the recurrent droughts, the water sector in Somalia/Somaliland has been greatly impacted. This relates to water shortages (quantities) then also reduced water quality. The main response activities that have been adopted to address the current water crisis are berked rehabilitation (SRCS), water trucking (other agencies), distribution of water purification tablets (SRCS), multi purpose cash, awareness campaigns related to hygiene promotion (SRCS). Regarding Anticipatory actions, there has been any actions yet due to the fact that there is no water monitoring and trigger mechanism in place. Assistance/response is based on the initial prioritization of target areas that SRCS conducts. The prioritization is based on assumed vulnerability per community based on Number of IDP camps in the area, number of women headed families, predicted IPC classifications etc. Activities such as berked rehabilitation are done in consultations with the communities and SRCS branches who flag/identify berkeds in need of repairing. Repairing may consists of re roofing/ roofing, and brickwork to strengthen the structure. The berkeds are meant to capture run off water in case of rainfall incidences. In cases where there hasnt been rains for a prolonged time then water trucks are deployed to deliver water to the communities. Cash has been an imoortattn modality to adress the water shortages. In the current prevailing drought, water and food insecurity crisis, water is now being sold by private players. So the cash has come in handy to t least enable the communities to buy fresh water for drinking. Water sources such as dug wells are often contaminated as livestock i,e camels, goats also drink water from those same water bodies as well.

Anticipatory Actions

The current recommendations for the development of triggers for drought focussed Anticipatory Actions are that these should be staggered and closely related to the development of the overall situation and local impacts.

Based on your experience, are water levels in berkads good indicators for drought impacts on the community? Could the indicator be enhanced by local knowledge?
Water levels in berkeds could be a good indicator, however it cannot be a stand alone indicator. This has to be combined by meteorological forecasts and local knowledge as well.

The ultimate anticipatory action would be the trucking of water to those who need it most. Going further, one could think about other anticipatory actions that could be triggered beforehand such as awareness raising, information dissemination and involving private berkad owners. What do you think about these proposed Anticipatory Actions? Which potentials and challenges do you see?
Awareness raising and information dissemination should be more on informing the communities on how to improve water quality at local level e,g boiling before drinking. Involving private berked owners is also feasible however their involvement could be limited as they are more concerned about their

business models i.e selling of the water and preserving their berkeds than being part of the overall response/Anticipatory action mechanism. Nevertheless there is the potential to work closely with the private berked owners. This can be done through rehabilitation of their privately owned berkeds in return for their involvement in response and anticipatory action activities related to addressing water shortages.

Do you possibly have other, more specific or different ideas for Anticipatory Actions?
yes, i) timely distribution of cash to enable communities to buy and stock fresh water
ii) timely distribution of water purification tablets
iii) timely rehabilitation of other water sources such as boreholes

Monitoring

To facilitate monitoring, the water levels need to be categorized.

Which water level categorisation do you think as useful? (e.g. how many categories?) How detailed does it need to be in order to be useful and how coarse does it need to be to remain monitorable? *These water levels are ideal i.e*
Empty (no water at all)
Critical (1 day of water supply remaining),
Low (3 days of water supply remaining),
Middle (5 days of water supply remianing)
High (full capacity)

Which water level category should trigger which Anticipatory Action? *Low category*

Which parameters should be monitored weekly, monthly or even only annually? *Water level (daily monitoring)*
Berked condition (annually)
Number of people accessing the water form the berked (weekly/monthly)

Water Quality

Can you think of ways in which water quality could be included in the monitoring process?
Water quality is difficult to monitor at community level as it is a technical activity. Unless if the SRCS through the branch staff are equipped with water testing equipment as well as training them on the water parameters to be tested.

Do you know of any solutions that have proven effective for local water quality monitoring by volunteers in your given circumstances? *I'm not aware of any.*

Resource limitations

How do you currently decide which community to help when resources are scarce?
The SRCS in consultation with the government select target communities based on a pre existing selection /vulnerability criteria based on either number of IDP camps etc

What are your experiences? - What would be good ways to deal with potential loss of trust and frustrations in the moment and possibly beforehand?
Utilise the community based SRCS volunteers to engage communities and sensitise the communoties on the riole the SRCS plays. Also establishing a robust feedback and Complaints mechanism that ensures communities can easily relay their feedback.

What other challenges do you see in regard to resource limitations?
The current crisis is huge and response activities are being overwhelmed by the need. This will lead to commercialization and overpricing of fresh water.

Berkads

In the beginning of the mapping and monitoring of Berkads, their location and related key information shall be captured. Determined key information are so far: the location,
ownership,
total number of people or communities dependant on the berkad,
its water storage capacity and
functioning
Which other social, technical or context related indicators, parameters or features would you add to this list of important information about Berkads in regard to Anticipatory Actions? Which challenges might arise in the capturing or monitoring of these information on site?
Other information might included the year it was built, the last time it was rehabilitated etc. However this kind of information might be missing as you need people with community/institutional memory to provide such kind of information. Somalis are highly mobile communities and it will be difficult to get information on past details per particular geographical area.

Does the community have an idea of how long the water of their water sources will last? How good is this prediction usually? *Yes they have an idea. These kinds of predictions are good as communities usually have their own control measures to ensure equitable distribution of water e,g how many containers per family etc. The berkeds are usually locked to ensure there is controlled acess to the water stored.*

Water Trucking

How does the trucking of water currently work? On what information do you act?

Which roles (e.g. funder, executer, manager, etc.) exist and who usually fills those?

What resources (human resources, finances, water, etc.) and how many/much of these are required for one action of water trucking?

How does the availability of water trucking is spread across Somaliland? Are there certain water points that are used for that?

How long is the average response time from getting the information to the filling?

Final remarks

Would you like to share additional experiences, lessons learnt or other key points?
It is proving to be a challenge to plan for anticipatory actions in an already prevailing crisis in Somalia/Somaliland. Already the needs are dire and the current SRCSs focus is on response mechanims to adres the already visible impacts of drought.

Is there anything else you would like to add or any final thoughts you would like to share before we conclude the questionnaire? *water monitoring is vital as it will inform decision makers on the priority areas to focus on. Community level water monitoring plus weather forecast information will help form robust Anticipatory Action systems as well as informed response mechanism.*

B.4 Questions& Transcript I3

Interviewer: Bosse Sottmann
Medium: Zoom
Interviewee,I: SRCS CBS Manager
Date: 04.03.2023

All right, maybe I just shortly introduce myself. I don't know how much you know or how much people told you. I'm Bosse. I'm a master's student at the University of Heidelberg and I'm currently writing my math thesis exactly about this topic. So I talked to you. You possibly know Melanie?

I: Yeah, my name is A. F. H. I3 is the last name.

Interviewer: All right. I'm sorry.

I: No problem. I'm called I3. Dr. I3 always. So no problem for that. I will write down in the chat my full name so that we can...

Interviewer: I'm sorry, Mr. I3. All right. Oh, I'm sorry for that. That is on my head.

I: No problem. It's okay. Always the people who are here call me I3 only.

Interviewer: Okay, how do I pronounce that?

I: Dr. I3.

Interviewer: Dr. I3. All right. Cool. So Mr. I3. Yeah, so I'm writing my math thesis right now. And in the context of this, I'm trying to figure out how we can best set up a monitoring and mapping approach for water sources and for berkeds in the region of Somaliland. And I already got some great answers from I1. And I would be super grateful if you could give me some more information. Twofold. Once on the project of NYSS and CBS. As I talked to I2 and she recommended me to talk to you because I'm not a big fan of the project. But I talked to I2 and she recommended me to talk to you because she said, you know, all the things which happened on the ground and you're the expert in that. And if you still have a bit more time, I'd be grateful to talk about some of the monitoring things I still have open questions to. If you're okay with that.

I: Okay. So can I start or you have a question that you would like to ask me question by question and then my answer for that.

Interviewer: I think it would be great just to. Of course, you can give a general introduction if you want, if you like. That would be great, actually. Okay.

I: Thank you very much. As already mentioned, my name is Dr. Abdifatah Hussein I3. So I would like to give you some information about community based surveillance and also NYSS platform. So when it comes to the community based surveillance, we started 2018 in Burao. The capital city of the Todgheer region, we piloted 75 community volunteers. And we piloted, we look at how community based surveillance is applicable in Somaliland. And what brought to our attention to establish community based surveillance at Buroa. This in Buroa, I mean in Todgheer region, there was a cholera outbreak 2017, which badly affected the communities in Todgheer region, and also other regions, but mainly badly affected in Buroa city, where about 700,000 people live in that area. And it came without saying or, you know, the cases was unpredictable and then it was escalating in the community and then they spread out all the community. So the problem came, you know, the people, for example, the Ministry of Health and the other people, they recognized that there is an outbreak and the outbreak at this peak. And then at that stage, SRCS or Somaliland Red Cross Society is, you know, at that time, giving warning and signals to the Ministry of Health and saying there is a cholera or acute water diarrhea, which is starting in these areas. And for many reasons, the Ministry was saying still the cases we have seen is still, you know, the normal cases we are getting from the communities or something like that. So the problem, you know, it reached this peak. And then at that time, SRCS and its sister organizations or BNS, they established, you know, SRCS, they sent the request that they can come to Somaliland to support so that, you know, the cholera can be managed, you know, because when it comes to the capacity of the government and also, and, you know, the magnitude of the disease became, you know, something which is not the government can not manage. In that case, we requested other national societies to come to Somaliland to support. So initially, Canadian Red Cross, they responded and then within 48 hours, they sent an ERU mission, Emergency Response Unit, so that they came here and they were well equipped with their vehicles and other medical logistics and staff and also the equipment which can be managed in the cholera outbreak. So they were having also what's called a tent for, in tent for cholera management, cholera treatment centers. We established that one and we were managing there for that time. And then again, we established what's called Oral Rehydration Points. So Oral Rehydration Points, we hired community volunteers, people who were provided training from the unit and then they went to the community, they are supporting the community because some people, when they have a diarrhea, they are not going to come to the health facility so that they can get the needed support because they were, you know, a bit reluctant to see other people that they have a diarrhea or, you know, have a stigma or something. So they were not happy to do that. But the Oral Rehydration Point, they supported us at the community level. So they were going house to house so that they can give health and health promotion activities in the same way. They were providing ORS, SYNC and also and other like aquatabs so that they can provide the water and something like that. In that case, this supported a lot. And, you know, the cases who are coming to the health facility or the cholera treatment center, they use it because they were getting support at the community level. In that idea, we said, as the SCRS, one of the lessons learned is that, you know, the cholera came to our country without saying. And we think about in the way that we can identify the cases in the community early enough so that we can identify and respond at community level. So we can stop, you know, an outbreak immediately when it has started or to be noticed early enough. So that's the idea. We came up with community-based surveillance. And as I already mentioned, we piloted and in the Todgheer region, we recruited 75 community volunteers and then the pilot became successful. Then at that time, we were focusing on three districts, Aynabo District, Oodweyne District, and Burao District. And then we scaled out to the other districts, like the Buhoodle District, which is in the Todgheer region. And then we again scaled up to the other regions and then we moved to Todgheer region and again Sool region. And last year [2022], we moved to Senaag region while the two rest areas and regions we scaled this year. So almost I can say now community-based surveillance reached all six regions in Somaliland. We are only focusing on the hotspot area where there is an epidemic, a prone disease areas or where we expect the outbreak to happen. We are not covering all the, for example, all the area, all the country. But we are covering the hotspot areas where we think that outbreak may start or happen. And there is a lot of outbreaks which the community volunteers identified and we have done investigation with the collaboration with the Ministry of Health. And then, you know, we still have that outbreak there. I can give you an example about that. For example, the first case of COVID-19 was from one of our community volunteers in the community. And then the Ministry of Health, they have done the investigation. They took the samples, they sent to Nairobi and then the case became positive. That's one thing. Okay. And the other thing I can mention is that they reported this kind of [fever] at community level. And then, you know, that case was solved at community level. We shifted mobile teams we have so that they can manage that cases. In the same way, there was a success, but I can say an outbreak of measles in the country. And then, for example, one community called a community volunteer in that community. He sent two cases of suspected measles. And one day after, he sent three others. And the next day, after one day, he sent three other cases. And so immediately, our community volunteers, I mean, our CBS officers at the regional level verified that it is much in the community case definition. If you may share, let me close the door. Okay, so that the cases, the Ministry of Health, SRCS team and again WHO together, they went into that community, they took samples and then they sent to the national lab for further investigation and the cases, two of the five cases became positive and then we have done mass immunization against the measles. And then at that time, I remember 5,300 children between age to nine months to nine years was immunized. So I think I can say is when it comes to the community based surveillance is one of the things that can easily detect early enough at community level, the health risk in the community and SRCS has mobile teams who can be deployed immediately within hours so that they can do the response. And also I would like to thank to the Norwegian Red Cross who are supporting this program to run since 2018 and then whenever there is an outbreak, we immediately request support and they profile the nearly support. So I think that is the general view of the CBS when it comes to the NYSS. We started and you know, it composes of, there is what I can say, instruments which you need when you are using NYSS. For example, you must have a mobile. So any mobile you can use it. So there is no need to have a smartphone but you are using SMS. So call an SMS. If you are using SMS, you will use at any mobile but the other thing is also there must be a network in that area and again SMS Eagle. SMS Eagle is a device which captures information which sends the community volunteers with a local member and then when it captures that information again, it uploads to the NYSS platform. So initially the NYSS platform, we are supporting the developers, the need at the community level. So whatever we need, we were discussing with them and then they were updating in that way. So it took around one year to build on but initially the NYSS platform, it captured the information but again we were downloading that information in the NYSS platform and then we manually analyzing through Excel format. But finally we reached a stage that the system or a NYSS platform can automatically analyze itself and again it can give you an alert if the [hella space] key reaches the threshold according to the geographical location that reports are coming from so that you can also early, so that you can get a message through your mobile or your email or something like that. So you can also flow up immediately when you get this alert and mobile all these things. So I think that's general view about the NYSS and also the CBS, how we started and all these things. Thank you and again if you have any further questions, please do not hesitate.

Interviewer: I do. Thank you so much first of all for this very good coverage and introduction. I learned a lot. How do you, what do you think about NYSS? Would you do it again and why did you decide to do this kind of crowd sensing or working with your volunteers? How did that work specifically? Do you know, so how do you recruit volunteers? How do you train them? How do you get into contact with them? Are they chosen? Could you tell me a bit more about those?

I: Yeah of course. Thank you very much for your question. For example when we are recruiting, I can't say, I cannot say recruiting. When we are you know going to get volunteers of that community, we go to the community.

Interviewer: Are you still there?

I: conscious or are you just promoting the idea of community? The person can read and write. Again, that the person willing to be to be a community volunteers. And again, that, you know, has a reputation of the community, good reputation in the community, willing to work on a voluntary basis because as I said, SRCS is not paying to our volunteers. So the person must be willing to be a volunteer. And again, the community, the community or the committees in that community themselves they were selecting that according to the criteria for that people. When they select and then we do assessment, small assessment, for example, how they can read or write or something like that. And then after that, then we, we let them to, to come together and then we provide training according to the community basis surveillance. When it comes to the [NECBHFA], when it comes to the ECV or ECVHRA and also ECV and also how to report health risks and in terms of coding and all these things. And then we provide that training. We send that, send back to their communities and then they start working with the community. There is a regional supervisor. So looking at the cases coming to the NYSS platform, if there is an error reporting, they immediately communicate to the volunteers and then they support to send them in the right format. So that is the way it works. So when it comes to the selection, the community they select, and then we are working the community leaders, the community committees and also community health committees. They are the one who are supporting when they are working with their communities. If there is a cases in their community, they are the one who is communicating to them. And some of the time the community volunteers, they go to the community by visiting, by doing a house to house visit and then see if there is a cases in the community. So their friends, community themselves, community leaders, they are the one who give us this information. And then we tell them if there is a health risk in that community to SRCS, its role is to come to the community to support them, to control that coming up disease in the community. So in that way, there is a good collaboration. The other thing I can mention is that, SRCS has a good reputation and image at community levels. So it is one of the most trusted organization in the country. So there is a strong relation at community level. So that it helps us also to do this program as community level.

Interviewer: Well, thank you. Great that you have so much trust in communities. Coming away from the NYSS and looking at the new project or water monitoring, could you possibly explain me a bit more about the local context at the moment? How is water managed and how does the community live on water and how do they do that? How do they manage their water currently?

I: Okay, thank you very much. And there is a recent years, or I can mention for the last five years, there was a recurrent drought which is happening in the country that is badly affected the communities in Somaliland. So always there is a water shortage, but in terms of, you know, and affording waterborne diseases, for example. We train community volunteers how to deal with that. For example, WASH component, or hygiene and health promotion activities they do at community level. So what they do is that they teach mothers, they teach the community how to prevent water contaminations and how to prevent water to be contaminated. Because there is a scarcity of water sometimes, one of the important thing is hand washing, what they do. And the people sometimes they will say to you, we don't have enough water. So how we can wash our hands? Because they will say, we don't have any enough water. But again, they give that information to the community so that they can be safe about waterborne diseases. So mainly what they do is to, for example, purify water treatment, like using apple tabs so that they can use, for example, one [tear cam], one tablet for that. And again, another method they use is water poly. So they boil water. If there is no, what is called an apple tab or something like that. But again, they teach how water can be contaminated. For example, when you are taking from the source, and again, when you are traveling with the water, and again, when you are storing the water in your home, or when you are using even the water, the process of contamination, they explain for that so that they can afford. Because if the water was clear when they get from the water source, again, during taking that water to home, in that period, the water can be even contaminated. So they do, and then, for example, when it comes to the berkeds, they use buckets. And berkeds, for example, animal and people, together they use the water in the berked. But what they do is that, to avoid contamination of water in the berked, they make trenches that water flows, and then animal can drink water outside the berked. And again, when they are using this water, they also cover this, and they cover the berkeds and all these things. So they do method, which they try their best to keep the water clean and to be safe when the people are using. Thank you.

Interviewer: Thank you very much for the answer. You talked about berkeds. So the goal, which also I1 proposed of this project, was early warning for water shortages. So if there is no, for example, no water anymore, we need to respond locally. What do you, could you think of early warnings or anticipatory actions before the last minute, before it's empty? So for example, the berked is half full. We try to, I don't know, raise awareness about it, or we can say we can't really do something or anything else, like, or we did distribute water purification tablets or so. Can you possibly think of anticipatory actions that you could relate to, like the water level in the berked and to which water level would you relate that?

I: Okay, thank you very much. And, you know, mostly it depends, because of when water shortage has already mentioned, there was a recurrent drought happening in Somaliland. And, you know, there is a, this recurrent drought is, you know, badly affected the communities. And then whatever source of water they can find is what they have. And sometimes they think about what they can drink for themselves instead of having other necessary things. And for example, when the, when there is a, you know, water shortage, it's just this, then they don't think of what kind of water they can get, whether it's bad or something like that. Sometimes there was water trucking and, you know, the SRCS or the other organizations, even the commercial or trade people, they were supporting to the communities who are in need, because this is, and then sometimes, when that water trucking comes, they put the water again to the berkeds. So initially they clean the berked, and again they put that water, but it is kind of water trucking so that they can take a long distance to the, for example, main cities, they travel, and then they put the water into the berked, it's again to fill it so that the community again uses it. This is costly and also has, you know, this, yeah, this time.

Interviewer: How does water trucking works? So who's doing the water trucking and how do you know to which community currently you need to go?

I: Okay, thank you very much. When it comes to the water trucking, it depends. For example, if there is, we do assessment and the community themselves, they talk themselves and then they say there is a lot of, there is a water shortage in their community, so they do, what is called, press release, or they do, yeah, it's called a, yeah. We do press release and then we say there is a water shortage in our community and also as there is FSAU which also sometimes reports the problems existing in the community and SRCS also has a good relation with the community and again that contact we have the community they communicated directly to the SRCS complaining about that there is a water shortage in the community and also the government they have a unit which you know works with the if there is an emergency something like that and supports the community so all these efforts together they decide where these resources include for example and SRCS they organize the resources available and then they go to the community communities who are you know most vulnerable and in that area so mostly it depends and the information coming from the build and then that information is analyzed when it's analyzed we look at where is the most priority area to build is going to be immediately.

Interviewer: Thank you very much. Can you think of what else would you like to monitor in regard to water besides the water level? Do you have anything else you would like to or which way you think it is useful to monitor via for example a volunteer who is sending a coded SMS?

Interviewer: Yeah actually when it comes to the water related diseases for example diarrhoea they were monitoring about that and they were closely watching that and then they were reporting any case for me this is the community case definition they are the one who's who's reporting on that and then we are also looking at the threshold if the case is reached the threshold immediately we provide in that area they also devil they offer to do hygiene and health promotion activities and also we notify the surrounding communities in that community to also to be notified to know that there is a increase in cases in that community. What they do is to you know tell and you know the community that there is a increase in cases of diarrhoea in the community due to the water related problems and in that case they were providing that information. Again they were reporting to SRCS and SRCS is again they go to the community they visit what they do is they if there is a lot of cases received in that community we shift a mobile team who can do case management at community level and that and you know the case management they do at community level and if there is needed another support it is the time that SRCS immediately you know and with the collaboration and with the Ministry of Health to contain the outbreak in that area so always it depends the scenario.

Interviewer: Thank you for your answer and the insights. How do you currently or for example a scenario the volunteer is sending that the berked is empty and that they don't have water or only very few water but all resources are taken and trucking is not possible. How could one prepare for that situation so that for example the SRCS does not lose trust and so how would you communicate and synthesize the community about the possibility that response might not always be possible?

I: Okay and normally community volunteers they are reporting health risks in the community, health related diseases in the community mainly those who can make outbreaks like good water diarrhea like measles, COVID-19 recently and and then the community so that the main you know and health risk is there looking at that community level so that's one thing. The other thing when it comes to the water for example as you mentioned if the water level of berkeds became you know less or scarce and then what they do is that they provide hygiene and health promotion activities but those who are community leaders are the one who tells the SRCS or other partners or the government that there is a water shortage but sometimes they buy themselves they collect the money between them then they buy water and then they use water trucking for themselves and then for example two or three families they go together they bring their money together and then they buy one water tank to take you know water to their community so that's what initial phase when they do but when you know for example the people they are depending on their livestock and then if there is a drought the livestock become weak or die and then when they see that they are not afford to buy this water or trucking that water this is the time they talk to the other NGOs or the government and say we need support when it comes to me and this only not only and when it comes to the water trucking not only for the government and not only for the NGOs and even the normal people they participate there is a you know people who are good willers and then try to get money from the people who are you know those who have something and then they gather that money and then they buy that money for water and then they distribute according to the need and how they are looking at where the magnitude of the they are looking at where the magnitude of the problem exists and then they refer this water to the to the community so in that case it has different levels so one they can manage themselves and the other level that they can request the NGOs and all these things and the last stage where everybody in the community whether in the urban or rural areas is participating to support each other and one of the good things i can mention is that you know the Somalis they support a lot each other when it comes to the disasters or something like that.

Interviewer: Great, thank you for your answer. Good to hear. I think one last question in regard to water quality. Do you know of a way locally how people can access or assess their water quality? So for example, the volunteer can see that the water quality in the berked is not good and now can ask for water purification tablets. Do you know of a way to monitor that locally?

I: Thank you very much for your question. When it comes to the volunteers, for example, water may be clear in colour, but when we are using it, it is contaminated. So we cannot decide by the colour. Actually, what they do is that is prevention, to do early prevention instead of waiting when the colour of the water changes or there is a remnant in the water or something like that can be clearly seen. What they do is that early enough when there is a water shortage, they tell the people if there is a water shortage, there is a lot of related waterborne diseases, mainly diarrhea is one of it. So that they provide hygiene and health promotion. How, you know, and SRCS, we distribute amount of aqua tablets per month or SRCS sink to the volunteers so that they can manage at community level if there is a case. So when it comes to the aqua tablets, they provide throughout the year so that the household level can be used because the end user is the household when water comes to their community, whether it's trucking or where it's berkeds or where it's surface water whatsoever. So, you know, early, what we train is for the community, volunteers is not to wait until the people become fall sick, but in a professional mechanism. So they do all these things. They do awareness raising, hygiene and health promotion sessions by doing, for example, group sessions by visiting house to house, visiting to meeting and all these things. And we're talking about that we thought that at that time is related, you know, what's going on in the community.

Interviewer: Thank you for your answer. I only have two more questions, if you're okay with that.

I: I'm okay, no worries.

Interviewer: Looking at this water monitoring approach. What are your thoughts about that? What would you wish for? How you can do you have any any more, you would like to add to that?

I: When it comes to the water monitoring. Okay. You know, in our context, water monitoring, when it comes to the urban areas, yes, water, there is an agency who is responsible for water supply. They do what's called a den, a chlorination of the water, and then they have the one who's responsible. So we don't have any issue with that. But when it comes to the rural areas, and nomad ares, is the way we have the problem. And, for example, mainly 70, around 70% of our community, they live in the rural areas. And then there is the, there, you know, there, where there's a lot of, you know, water trucking and then berkeds use and all these things happening. So in that case, as a SRCS, what we do is to provide any necessary support at the community level. When it comes to the monitoring of one of one of that. For example, when we do rehabilitation of berkeds, we also train the community themselves is the proper use of the berkeds, and then the safety of the water. And again, how you know to monitor that the water is contaminated. For example, one of the things that contaminated water is, is the, you know, when they are using the, the water themselves because they were when they are using or taking water from the berked is that that is the time that they can contaminate. So we provide a training, the community, and also we give them was called the ownership of the of the berkeds if the SRCS rehabilitated or build a berked for for them. It is not for SRCS for the community so the community think take the responsibility to monitor and, and, you know, and have the ownership of the berkeds and all these things.

Interviewer: Thank you. I mean, one, one additional question, and because how big our berkeds, usually, how long does water last.

I: You know, it depends. The community who are using it. Sometimes it can last within three months, sometimes it can last one month. Sometimes it can last for half a year.

Interviewer: Okay. Yeah, well thank you. Yeah, I was just wondering if it's just like a week or a month. So that gives me some more information. For the last question, would you like to add anything else would you like me to know something that I should not forget, or which, on what should I focus. What do you think, do you have anything more you would like to add?

I: Okay, thank you very much. What I would like to add is that, for example, when it comes to the NYSS and NYSS platform. We have the system or the NYSS platform is very effective and very supportive. And we can identify immediately if there is a health risk in the community. Also, we have sometimes a challenge about the SMSeagle. Because the SMSeagle is a device that, for example, captured all these messages coming from the community and also uploaded to the NYSS platform, which is cloud based. In that case, sometimes there was a problem about the function of the SMSeagle. So, several times we have encountered that it failed. And then we have got a gap to get these reports. So that gap sometimes can carry it not to identify early enough if there is a, you know, health risk coming from the community. So that's one of the issue I would like to highlight. The other thing is okay. Thank you very much. Really appreciate it.

Interviewer: Thank you so much for your time, Mr. Balidi. It helped me a great, great lot to understand. It's not always easy to understand things from so far away, but I try to do my best and I'm very thankful for your help.

I: Okay. Thank you very much. And anytime you have a question, I will be available for you to support your thesis.

Interviewer: Thank you. Oh, it's just not only for my thesis. I want to do good work so you can continue helping people and do your job. I would like to support that. That's all.

I: Okay. Thank you.

Interviewer: Thank you very much for your time.

I: Okay. Bye. Bye.

Interviewer: Bye.