Modernisation and farmer-led irrigation development in Africa

A study of state-farmer interactions in Tanzania

Chris de Bont

Academic dissertation for the Degree of Doctor of Philosophy in Geography with Emphasis on Human Geography at Stockholm University to be publicly defended on Thursday 14 June 2018 at 13.00 in Ahlmannsalen, Geovetenskapens hus, Svante Arrhenius väg 12.

Abstract

After years of relatively low investment, irrigation development in Africa has been put back on the policy agenda as a way of increasing agricultural productivity. In spite of existing evidence of farmers' irrigation initiatives across the African continent, current policy prescriptions still revolve around (large-scale) state intervention. Farmers' irrigation initiatives are generally considered traditional, backward, and unable to contribute to the agrarian transformation that many African nations are after.

This study aims to problematize this narrow notion of farmers' irrigation initiatives, and explores how underlying ideas of modernity/modernisation influence irrigation policies and interactions between farmers and the state. Focusing on Tanzania, this thesis consists of an introductory chapter and three separate studies.

The first study is a historical analysis of the state's attitude towards irrigation development and farmers' irrigation initiatives in Tanzania. It shows how historically, the development narrative of 'modern' irrigation as a driver for agricultural transformation has been successful in depoliticizing irrigation interventions and their actual contribution to development.

The second study engages with a case where farmers have developed groundwater irrigation. The study analyses how differentiated access to capital leads to different modes of irrigated agricultural production, and shows the variation between and within farmers' irrigation initiatives. It also illustrates how an irrigation area that does not conform to the traditional/modern policy dichotomy is invisible to the government.

The third study concerns a farmer-initiated gravity-fed earthen canal system. It shows how the implementation of a demand-driven irrigation development policy model can (inadvertently), through self-disciplining by farmers and a persistent shared modernisation aspiration, turn a scheme initiated and managed by farmers into a government-managed scheme, without actually improving irrigation practices.

Together, these studies show how modernisation thinking has pervaded irrigation development policy and practice in Tanzania, influencing both the state's and farmers' actions and attitudes, often to the detriment of farmers' irrigation initiatives.

Keywords: *irrigation development, modernity, modernisation, farmer-led irrigation development, expert knowledge, Tanzania, sub-Saharan Africa.*

Stockholm 2018
http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-155644

ISBN 978-91-7797-224-2
ISBN 978-91-7797-225-9
ISSN 0585-3508

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ISBN print 978-91-7797-224-2
ISBN PDF 978-91-7797-225-9
ISSN 0585-3508

Printed in Sweden by Universitetsservice US-AB, Stockholm 2018
Distributor: Department of Human Geography

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Acknowledgements

Writing these acknowledgements gives me the opportunity to take a minute to think of all the people who have helped me to complete this book, and to realise how privileged I have been to have all of them around me. Although my name is on the cover of this thesis, and at times the process was a lonely one, I was supported by so many people, both near and far, throughout the past four years. This is my chance to thank them.

Let me start with my supervisors, whose academic and personal advice made this PhD a lot more doable and enjoyable. Lowe, thank you for believing in me and my work, even when I had trouble seeing what I was doing. Your encouragements, comments and continued presence made all the difference. I will keep telling myself to be bold! Gert Jan, you were the one who first sent me to Tanzania in 2012 and set me on the path towards this PhD. Thank you for all the discussions, comments, and opportunities you have given me. I would not be in the same place today if it was not for you. Mats, thank you for being there in the background throughout this PhD, and especially for your support and feedback towards the end: your comments were always sharp and insightful.

My PhD was funded by the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration, as part of the Resilience in East African Landscapes (REAL) project. I am grateful to the funder for making my work possible, and to the REAL project for the many wonderful people I met, the places we travelled and the things we learned.

I am indebted to the Institute of Resource Assessment at the University of Dar es Salaam, and specifically to Madaka Tumbo and Faustin Maganga, for supporting my research permit application, and to the Tanzania Commission for Science and Technology for granting me permission to do this research.

The Studying African Farmer-led Irrigation (SAFI) project provided me with the opportunity to do research with one of their junior researchers, and invited me to several workshops. Thank you for including me in your project, and for providing me with a research community interested in farmers developing irrigation in Africa. A special thanks to Phil Woodhouse for his feedback on an earlier version of this thesis during my final seminar.

Living between three different countries makes that there were people supporting me both directly and indirectly. When in Sweden, I spent more time at the department of Human Geography than anywhere else. Thank you to all

my colleagues, who I saw more than family or friends, and who helped me in uncountable ways to get to the end of this PhD. I especially found much pleasure in sharing the trials and tribulations of this process with my (ex-)PhD colleagues, thank you all for the emotional and practical support over the past four years! Let me single out Annemiek, my REAL buddy, for all the times we shared hotel rooms, went all over for courses, had fun and shared our struggles of moving from Wageningen to Stockholm. Thank you for sharing this PhD life with me, and for, together with Lennert and Karen, making sure I did not completely forget my mother tongue! Lennert, thank you for all the great times in the office. I know I kept complaining about that open window, but you made the every-day stuff so much more fun. Natasha, I am so grateful for your sound advice along this PhD journey, for helping me put things into perspective, and the musical encouragements in the final days! Emmeline, thank you for always welcoming me to your home, especially when I had nowhere else to go. With Stockholm's crazy rental market, it was wonderful to know I wouldn't end up homeless. Outside academia: Katrin, thank you for your friendship and eternal optimism, your genuine interest in me and my work, and for making me part of your family in Stockholm. I am following you to East Africa soon!

In the Netherlands, Wageningen remained home. Thank you to my friends, who welcomed me every time, gave me a place to stay and allowed our friendships to continue as if we were still living around the corner from each other. I also greatly appreciate the people at the Water Resources Management group at Wageningen University, who let me stay for two months while I worked on my thesis. It was great to be welcome, and to surround myself once again with water people. Of course there are those who left Wageningen, but who continued to be a part of my life. Martine, you are a great friend, and although Groningen was a bit out of the way, every time we did see each other only cemented that. Thank you for knowing all the non-academic parts of my life, and thereby reminding me that I am not just my work. Nicole, thank you for being there during the last months of my PhD, and for thinking of those things that my PhD-filled brain could no longer care about.

In Tanzania, I want to thank all the people who took the time to talk to me and help me with my research: the employees at the Zonal Irrigation Unit, the District Office and the Pangani Basin Water Office in Moshi, and especially the many men and women in Kahe ward. Your stories became a part of me forever. Special thanks also to my research partner Muthio Nzau, one of the kindest and strongest women I have ever met: your perseverance and commitment are inspiring! I am especially grateful to my research assistants Honorata Mselle and Nailijwa Mkwavi, for sharing the pleasures and hardships of fieldwork. I could not have done it without you. I also want to thank the Sisters in Moshi, who took care of me beyond giving me a place to stay. Thank you for letting me be part of your community for a while.

I am forever grateful to my parents, whose faith in me has never wavered. Papa, thank you for always being proud of me, even if you had no idea what I was doing. Mama, I know you sometimes regret driving me to Wageningen for that open house day, and encouraging me to study something that would take me away from you. Thank you both for taking such an interest in what I do, and for embracing everything and everybody that has become part of my life over the years. You have always been the foundation on which I build.

Thijs, my big brother, thank you for always being there in Tilburg while I roam around the world. It is a great comfort to know that you are there whenever I come back, and that there is somebody to fix the computer, lift heavy things and mow the lawn whenever papa and mama need it!

And finally, to Hans: This PhD process brought me home, but also took me away too many times. Thank you for sharing both good and bad moments with me, for your reassurance, support and love, for encouraging me to apply for this PhD in the first place and for standing by me throughout. I feel privileged and proud to share my life with you in so many ways, and hope that I am now coming home for good. Amari mada jal.

Stockholm, April 2018
Chris de Bont

List of articles

Article I

De Bont, C. The continuous quest for concrete and control in African irrigation planning: the case of the lower Moshi area, Tanzania (1935-2018). Submitted to Water Alternatives.

Article II

De Bont, C., Komakech, H. C. and Veldwisch, G. Neither modern nor traditional: farmer-led irrigation development in Kilimanjaro Region, Tanzania. Re-submitted to World Development after revisions.

Article III

De Bont, C. and Veldwisch, G. Farmers' modernisation aspirations and the policy practices of demand-driven irrigation development. Unpublished manuscript.

Co-authorship

Article I

CdB is the sole author of this article.

Article II

CdB conceptualised and designed the study, executed the qualitative fieldwork, analysed the qualitative and quantitative data, drafted the manuscript, made the figures and maps and revised the article after peer review. HK and GV both designed the questionnaire which supports the quantitative analysis in this article. They also both contributed to the manuscript through content discussions and participated in the review process by providing inputs on possible changes. In addition, HK organised the mapping of the wells and the implementation of the questionnaire.

Article III

CdB conceptualised, designed and executed the study, analysed the qualitative data, drafted several versions of the manuscript and created the maps and figures. GV contributed to the development of the research and the analysis of the results through repeated discussions, feedback on the draft manuscripts and written additions to the introduction and the empirical sections.

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Abbreviations

DO	District Office
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
LMIS	Lower Moshi Irrigation Scheme
NAFCO	National Food and Agricultural Cooperative
NGO	Non-Governmental Organisation
NIA	National Irrigation Act
NIC	National Irrigation Commission
NIDS	National Irrigation Development Strategy
NIP	National Irrigation Policy
PBWO	The Pangani Basin Water Office
SAFI	Studying Farmer-Led Irrigation Development
TPC	Tanganyika Planting Company
URT	United Republic of Tanzania
VEO	Village Executive Officer
ZIU	Zonal Irrigation Unit

Introduction

‘He says Black People are primitive
and their ways are utterly harmful
their dances are mortal sins
they are ignorant, poor and diseased!

He says I am just a village woman
I am of the old type
and no longer attractive
He says I am blocking his progress’

Okot p’Bitek, 1966, Song of Lawino[1]

The 1966 work ‘Song of Lawino’, by Ugandan poet Okot p’Bitek, tells the story of a woman, Lawino, who laments her husband who has started to emulate the White Man in an attempt to be modern. In the process, he condemns the traditional practices and values of the village he grew up in, and scorns his wife. In a vivid way, the poem captures one of the main themes in this thesis: the idea of modernity and modernisation as a state or process in which the Global North is the touchstone of progress and development, while ‘traditional’, indigenous ways are rejected. Relating this kind of thinking to irrigation development in Africa, this thesis starts from the observation that African irrigation policies still prescribe external (state) intervention to develop ‘modern’ irrigation, while farmers’ irrigation initiatives are written off as a thing of the past. With state irrigation planning focussing primarily on government investments in large-scale projects, designed according to engineering principles, and managed by formal irrigation institutions, farmers’ irrigation initiatives are generally ignored in formal policy, or merely recognised as in need of rehabilitation or formalisation (Box 1). Using Tanzania as a case study, this thesis aims to counter this narrow understanding of farmers’ irrigation initiatives, and to shed light on how the state’s engagement with these initiatives shapes their development trajectories.

Modernity/modernisation thinking is not only defined by the dichotomy it supports between the Global North and the Global South, modern and traditional, developed and developing. It is also strongly characterised by an emphasis on man as a rational being and a matching technological optimism: the belief that science can be used to conquer nature for the benefit of humankind.

[1] Citation comes from the 1984 translation from Acholi to English (P’Bitek 1984, 36)

In spite of the similarities between the two concepts, modernity and modernisation originate from very different periods and circumstances. The idea of modernity stems from 19th century England, where it initially indicated a radical societal transformation after the industrial revolution (Wagner 2014). Modernisation theory on the other hand, was dominant in the United States during the 1950s, 60s and 70s, where it was developed to understand what would happen to nations in a postcolonial world (Gilman 2004b). While the glory days of modernity/modernisation thinking might be several decades behind us, its legacy can still be felt today (Mbembe 2001).

Box 1: Modernisation elements in African irrigation policies

Modernisation is central to many African irrigation policies and programs. Here, I highlight a few, providing explicit quotes or describing implicit modernisation elements of different national policies.

Ethiopia: The National Irrigation Policy distinguishes between traditional (built by farmers) and modern irrigation (built by the government or private investors). All interventions are directed to the latter (FDRoE 2002)

Kenya: From the National Irrigation Policy: The 'irrigation sub-sector growth will be driven by *research, science and technology* in order to attain high productivity and meet quality standards' (RoK 2015, 25, emphasis added)

Rwanda: From the Irrigation Master Plan: 'Desirable elements of *modern irrigated agriculture*: A *strong central organization*, supported by a *comprehensive water laws*, empowered to *plan and design* efficient irrigation systems, allocate water use and impose sanctions' (RoR 2010, 158, emphasis added)

Uganda: The Irrigation Master Plan describes irrigation as a tool to modernise agriculture and transform it from a traditional to a commercial sector. There is no mentioning of farmers' irrigation initiatives (RoU 2011)

Woodhouse (2012) gives an indication of the nature of this legacy when discussing views on African agriculture, rural society and its trajectories. He identifies two major opposing discourses, which are so dominant that many researchers and policy makers cannot see beyond them. First, there is the modernist discourse, which claims that 'unproductive and environmentally destructive traditional farming must be transformed by modern technology to enable rural households to develop from a 'subsistence' mentality to a more commercial outlook' (Woodhouse 2012, 110). Second, the conservationist discourse argues the radical opposite and states that 'indigenous technology [is] more attuned to local ecologies and less likely to provoke radical and destructive disturbance of natural systems of environmental regulation' (ibid, 106) and should therefore be at the core of agricultural development.

The debate on irrigation development in Africa reflects similar essentialist thinking, although the modernist discourse has always been dominant. It began with the colonial occupation of Africa, which signalled the start of large-scale state irrigation planning. Often, interventions took the form of fully controlled irrigation settlement schemes, through which the colonial state aimed to transform the agricultural sector in order to remedy overpopulation, land degradation and low agricultural productivities (Bolding 2004). Diemer (1990) describes the 'engineering paradigm' (p. 209-2010) underlying these settlement schemes, which prescribes the use of formal engineering structures to control water in order to use it as efficiently and productively as possible. He likens the resulting irrigation schemes to factories, in which farmers function as workers tasked with securing the maximum level of production. The most well-known examples of this kind of factory schemes are the Mwea scheme in Kenya, the Office du Niger in Mali and the Gezira scheme in Sudan. Although the engineering paradigm has its roots in colonial times, many paradigmatic schemes were built after African states gained independence (Diemer 1990; Ertsen 2008). With the support of international donors such as the World Bank, the 1960s and 1970s saw independent states implement large-scale government irrigation projects in for instance Senegal, Nigeria and Kenya (Adams 1992). However, by the 1980s, it became clear that irrigation investment in Africa had not had the desired results: in spite of heavy investments (Inocencio et al. 2007), irrigated areas were smaller than projected and agricultural productivities lower than expected (Moris and Thom 1985; Moris 1987). Scholars pointed at the mismatch between farmers' objectives and projects implemented by the state, and a lack of general understanding of local contexts to explain the poor performance of large-scale irrigation projects (Moris 1987; Moris and Thom 1990; Diemer and Vincent 1992; Diemer 1990; Adams 1992). In light of the disappointing results, irrigation lost its prominent position on the policy agenda of many donors and African governments, and funding for irrigation development in Africa decreased strongly during the 1990s (Lankford 2005). The general trend of the 1990s of reduced state involvement and an increase in participatory approaches (Ellis and Biggs 2001) was also reflected in irrigation planning. Generally, the policy paradigm became 'more market, more users, less state, better technology' (Bolding 2004, 12).

The conservationist discourse identified by Woodhouse (2012) is reflected in the views of proponents of indigenous irrigation technology, whose admiration for farmers' irrigation initiatives rests on their perceived longevity and linked sustainability (Stump 2010; Adams and Anderson 1988): if these systems have existed for so long, this kind of irrigation must be sustainable. As mentioned before however, this discourse remained marginal compared to the modernist discourse in which formal engineering was key.

After twenty years of relatively low public investment, irrigation reappeared on the policy agenda in the late 2000s (You et al. 2011). This renewed

attention also rekindled the debate on what irrigation technology was best suited for African contexts, at what scale it was to be developed, and by whom. In other words, what constituted the 'right irrigation' for Africa (Lankford 2009). However, in spite of the disappointing results of the past and ample evidence of farmers' irrigation initiatives on the continent[2], the current policy answer to the irrigation development question is once again investment in large-scale irrigation, by governments, private actors or a combination of these (so-called public-private partnerships) (Woodhouse et al. 2017).

Woodhouse et al (2017) argue that the preconceived and narrow notions of what farmers' irrigation initiatives look like and what kind of agriculture they can facilitate are the reason that policy-makers and planners are still largely blind to farmers' irrigation initiatives. Even when irrigation is developed at a smaller scale, policies generally place all responsibility for irrigation development with the state, and farmers' irrigation initiatives are largely ignored. In the Rwandan and Ugandan irrigation master plans for instance, 'informal' irrigation is briefly mentioned as irrigation that was developed by farmers without technical assistance, but is then ignored throughout the rest of the policy (RoR 2010; RoU 2011). In the Kenyan irrigation policy, there is no irrigation category covering farmers' irrigation initiatives, nor are farmers' irrigation initiatives mentioned anywhere in the document (RoK 2015). This is especially noteworthy since there have been ample studies and publications on different Kenyan irrigation systems built by farmers (Watson, Adams, and Mutiso 1998; Fleuret 1985; Davies, Kipruto, and Moore 2014). In all three policy documents, the importance of 'formal' irrigation reflects the past and current ambitions of African states to control the nature, location and extent of irrigation development.

To facilitate the recognition of farmers' irrigation initiatives, Woodhouse et al (2017) propose a research agenda which does not focus on characterising the outcomes of irrigation development, but rather draws attention to the processes through which irrigation is developed. They use the concept of 'farmer-led irrigation development' to describe 'a process where farmers assume a driving role in improving their water use for agriculture by bringing about changes in knowledge production, technology use, investment patterns and market linkages, and the governance of land and water' (Woodhouse et al. 2017, 216).

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[2] Farmers' irrigation initiatives in Africa include the diversion of rivers and streams in mountainous areas through earthen canal (Tagseth 2010), the use of shallow groundwater in valley bottoms (Adams 1993), pump irrigation from groundwater and surface water (de Fraiture and Giordano 2014), and urban agriculture irrigated with waste water (Drechsel and Dongus 2010). These initiatives can be individual and communal, and can cover anything from a few hectares for a single petrol pump, to more than 100,000 hectares of canal irrigation in the border area between Mozambique and Zimbabwe (Beekman, Veldwisch, and Bolding 2014). Crops vary from staple crops such as maize to rice and horticultural crops. For an elaborate overview of farmers' irrigation initiatives in Africa, see Woodhouse et al (2017).

In this thesis, I use Tanzania as a case to present an analysis of how the state engages with African farmer-led irrigation development and how this influences the development trajectories of these initiatives. Analysing past and current irrigation development projects as efforts reflecting a certain development discourse, rather than as neutral activities, I contribute to a better understanding of modernisation paradigms in both African irrigation bureaucracies and African farming communities. To do this, I first briefly introduce the main themes in public irrigation planning in Tanzania, and explain why the country is a suitable case for this study. I conclude by formulating the aims guiding this research, before introducing my conceptual framework.

Public irrigation planning and farmers' irrigation initiatives in Tanzania

Tanzania's pre-colonial, earthen canal systems are, together with similar systems in Kenya, unique in Africa due to their longevity and extent (Adams and Carter 1987). As such, they have long influenced the country's irrigation policies and programs (Teale and Gillman 1935; Water Master Plan Team 1977; URT/Nippon Koei 2002). Since colonial times, the state has tried to intervene in the institutional and/or infrastructural configurations of these farmer-initiated irrigation systems in an attempt to modernise them (URT 1994; URT 2016; de Bont 2018c, this thesis). The main interventions were the construction of river intakes and measurement structures, and the lining[3] of canals (Teale and Gillman 1935; Halcrow and Partners 1962; World Bank 2004). The primary reasoning was that controlling abstractions by farmer-built irrigation systems would lead to water savings and more efficient water use, freeing up water for downstream users. In addition, the state attempted, and at times succeeded, to build new, 'modern' irrigation systems for smallholder farmers according to standardised engineering principles (de Bont 2018c, this thesis).

This strategy of state intervention is still reflected in the 2016 National Irrigation Development Strategy's categorisation of farmers' irrigation initiatives as 'traditional': 'characterised by poor infrastructure, poor water management and low yields' (URT 2016, 7). This means that farmers' irrigation initiatives cannot contribute to the vision of the 2010 National Irrigation Policy, which is to have 'irrigation and drainage infrastructure which enables *efficient* utilisation of water and exploiting the vast irrigation potential area in the country for crop growth in highly *productive*, *modernised* and *commercial* irrigation schemes' (URT 2016, 11, *emphasis added)*. The only way to be-

[3] The lining of canals is the construction of canals with masonry and/or cement, often done to prevent conveyance losses.

come an efficient, productive, modernised, and commercial 'improved irrigation scheme' is to '[receive] interventions through support from the Government and/or Development Partners' (ibid, p.16).

These irrigation categories in which farmers' irrigation initiatives are considered traditional and inferior, and therefore per definition (literally) in need of external intervention, show that although the Tanzanian government actively recognises and engages with farmers' irrigation initiatives, this engagement is blind to the many different types of irrigation and their possible contributions to agricultural production and rural development. Tanzanian irrigation policies, like those of other African countries, are based on a firm belief in state control over irrigation development, as well as the conviction that formal engineering should be at the basis of any irrigation initiative. As in many other African countries however (You et al. 2011), public irrigation development in Tanzania has not been effective in increasing the formal area under irrigation, with the actual irrigated acreage falling well short of development targets (URT 2016).

The explicit use of the terms modern and traditional as policy categories in Tanzanian irrigation policy makes the pervasive modernisation drive of the state more explicit than in most African countries, where farmers' irrigation initiatives are still simply ignored and are often much more recent. The resulting active engagement of the Tanzanian state with farmers' irrigation initiatives provides the opportunity to study the interactions between farmers and the state, in a way that can inform discussions about the role of farmers' irrigation initiatives in a policy environment influenced by modernisation thinking.

Research aim

The tension that results from policy centred on state intervention and formal engineering, and an irrigation sector that is in practice strongly driven by farmers' initiatives is at the core of this thesis. In sub-Saharan Africa in general, and in Tanzania specifically, the emphasis in irrigation policies and programs is still on external intervention to realise 'modern' irrigation, while farmers' initiatives are written off as a thing of the past. In this thesis, I aim to contribute to the debate on the future of African irrigation development. I do this by challenging the narrow notion of farmers' irrigation initiatives, by exploring how ideas of modernity/modernisation influence state engagement with farmers' irrigation initiatives, and how this in turn influences their development trajectories. By doing this, I contribute to a better understanding of modernisation paradigms in both African irrigation bureaucracies and African farming communities.

In order to further clarify what I mean by modernity/modernisation thinking, and how I see its legacy in irrigation development and irrigation modernisation, I first elaborate on these concepts in the following sections. I then pose my research questions, and continue with a further description of irrigation development in the Lower Moshi area in northern Tanzania, where I conducted this research. After setting the scene, I elaborate on my methodology and give a summary of the three articles that form the empirical base of this thesis. I conclude by answering the research questions.

Conceptual framework

This section introduces my understanding of farmer-led irrigation development and state-initiated irrigation modernisation as hydrosocial processes which are shaped by, and reflect, specific configurations of power. To arrive at this conceptualisation, I start by discussing the concepts of modernity and modernisation, and follow this up with how these concepts are reflected in the common understanding of irrigation development in general, and irrigation modernisation specifically. I argue that this common understanding is blind to the political side of irrigation development processes, and introduce the hydrosocial cycle and waterscape concepts as a way to re-politicise irrigation modernisation and irrigation development. In the final section, I describe how this reasoning leads me to conceptualise farmer-led irrigation development and state-initiated irrigation modernisation as simultaneous, yet different, hydrosocial processes. I explain how this conceptualisation guides my analysis of the interactions between social actors, technology, fields, crops, and water, while emphasising the importance of the underlying narratives normalising and justifying those interactions. Analysing how narratives of modernity and modernisation influence irrigation development processes, helps me to re-politicise these processes and shed light on irrigation development in not just Tanzania, but sub-Saharan Africa as a whole.

Modernity, modernisation and the expert

As mentioned in the introduction to this thesis, Woodhouse (2012) identifies two main discourses surrounding the future of African agriculture: the conservationist and modernist discourse. The modernist discourse claims that 'unproductive and environmentally destructive traditional farming must be transformed by modern technology to enable rural households to develop from a 'subsistence' mentality to a more commercial outlook' (Woodhouse 2012, 110). This description reflects some of the broader scholarly meanings of modernity (especially the need for a radical break or transformation, see below), but also illustrates the many possible colloquial uses of the term modern, with 'modern technology' referring to anything from 'the latest invention' to 'technology based on scientific principles'. In scholarly work, modernity as a concept has its origins in 19th century Europe (Wagner 2014), while modernisation theory became popular in America after 1950 (Gilman 2004b; Ekbladh

2011). Both concepts however, are part of the same tradition and still influence, directly or indirectly, current interventions and development planning in the Global South today. Below, I start by quickly reviewing the history and meaning of the concept of modernity, and emphasise its colonial roots and post-colonial legacy. I then move on to modernisation theory and how it relates to the earlier ideas of modernity. I conclude by highlighting one of the main aspects of both modernity and modernisation: the role of specific types of expert knowledge in defining problems and solutions.

The concept of modernity was initially used by 19th century European scholars to understand the societal changes after the French and Industrial Revolution (Wagner 2014; Mahmoud 2015). Although scholars had varying interpretations of these changes and the new social configurations that were appearing, they agreed upon several elements of modernity: there was a radical break between what came before and what was now, people were autonomous individuals, and these individuals were rational beings (Wagner 2014, 137). This emphasis on rationality, alongside rapid technological advancement, led to technological optimism: the assumption that it would be possible to gather knowledge of both the physical and the social world and use that knowledge to control and improve the human condition (Kivisto 2010).

However, modernity was in no way a neutral term to describe societal processes. Gilman (2004a) remarks that already in 1860, William Thackeray, an English writer, suggested that 'printing and gunpowder tend to modernise the world' (Thackeray, quoted in Gilman 2004a, p.28). Gilman sees this as the start of the notion of modernity as something that other societies should aspire to, rather than a descriptive term for a period of European history. This is clear when realising that postulating that there is such a thing as 'modern', automatically means that there is such a thing as 'not-modern', 'ancient', 'archaic', 'outdated', or 'traditional'. Latour speaks of the moderns being considered 'winners' and the ancients being 'losers' (Latour 1993, 10). Olwig (2002) does not only observe that the modernity paradigm prescribes the existence of winners and losers, but also that the world of losers has to be demolished to make room for modernity. He outlines a process of progress based on a linear advancement through certain stages, in which what lays ahead is better than what is left behind. In fact, past experiences limit progress, and should therefore be wiped out. This destructive force is what he calls the 'dialectic of modernity' (p. 24).

With the concept of modernity conceived during the European colonial period by European scholars, it is perhaps unsurprising that soon Europe was postulated as the modern 'winner', while colonised peoples were the traditional 'losers'. Mamdani (2012) shows this by analysing the work of Sir Henry Maine, a British jurist and historian, who made a division between 'customary' and 'modern' law, and linked the former to 'natives' and the latter to 'settlers'. By making this distinction, and then stating that customary law held back progress because it was rooted in history and culture, colonised peoples

were excluded from possible development. This division between irrational, traditional natives and rational modern settlers was used to legitimise the continued colonisation in Africa and beyond until well into the 20th century (Gilman 2004a). Mbembe (2001) argues that even today, social science traditions take the West as a unique, distinctive social configuration, compared to which 'other societies are primitive, simple, or traditional in that, in them, the weight of the past predetermines individual behaviour and limits the areas of choice - as it were, a priori' (Mbembe 2001, 8).

This continuation of the image of Africa (and other colonised regions) as traditional and underdeveloped was cemented in the modernisation theory that became popular among American scholars in the 1950s (Gilman 2004a, 24; Wagner 2014; Ekbladh 2011). A response to the (impending) independence of many African nations, modernisation theory attempted to understand the economic, political and social change that was to occur in a postcolonial world. Replicating the idea that there are 'traditional' and 'modern' societies, modernisation theory assumed 'a common and essential pattern of 'development,' defined by progress in technology, military and bureaucratic institutions, and the political and social structure' (Gilman 2004b, 3). Essentially, the new nations only had to 'remove obstacles stemming from 'tradition' so that one's own society could follow the path of the more advanced ones and become like them' (Wagner 2014, 135).

It was modernisation theory that drove the development projects that became so prevalent in the decades after African states reached independence.[4] Modernisation as a prescriptive process became the core of development thinking in the decades after the second World War (Ekbladh 2011). As African states were simply traditional, they had no context and no history that should be taken into account: all traditional countries were seen as having similar problems, and requiring similar solutions (Gilman 2004a).

While modernisation theorists saw themselves as radically different from the former colonial powers, the assumptions they made, the solutions they proposed and the approach they advocated were remarkably similar. As already argued, the West (now Western Europe and the United States) was still seen as the example of modernity that 'traditional' nations should emulate (Ekbladh 2011; Wagner 2014). Furthermore, modernisation theory put its faith in science and technology to facilitate the modernisation process, while promoting state planning and intervention as the best way to secure the desired changes in society (Gilman 2004a). Gilman (2004b) identified three forms of modernism: technocosmopolitan modernism, revolutionary modernism and

[4] Ekbladh (2011) discusses the difference between modernisation and development, as both have been used synonymously at times. He sees modernization as the specific type of development thinking that was prevalent in the US (and globally) between 1950 and 1970. Development is a broader concept, which 'is closely bound up with the larger idea of social change and progress implicit in modern societies' (p.12).

authoritarian modernism (p.9). Where the first builds on tradition, the second sees the need for a radical break from everything traditional. The final one is the same as what Scott (1998b) calls an 'authoritarian high modernist ideology': 'a strong, one might even say muscle-bound, version of the self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature (including human nature), and, above all, the rational design of social order commensurate with the scientific understanding of natural laws' (p. 4). While the idea of what it means to be modern is similar to the other forms of modernism, this ideology is different due to the use of coercion and force to realise modernisation (Gilman 2004b).

While modernisation theory as a driving force in international development is said to have had its demise in the 1970s (Gilman 2004b), its legacy can still be seen in development projects today. Especially the belief in the ability of science and technology to improve the human condition, which was so dominant in both modernity and modernisation thinking, is still a key feature of many development interventions. In addition, the Global North remains a reference point for what is considered modern, which further drives the types of knowledge deemed relevant and the interventions proposed. Over the last decades, scholars have shown how the combination of these aspects makes that technical experts (those trained in 'Western' science) hold a powerful position in defining both the problems and solutions for countries in the Global South. Ferguson (1990), in his work on development interventions in Lesotho, showed for instance how a development discourse was created in which Lesotho was portrayed as a peasant society isolated from the cash economy, and in need of an agriculture-oriented national development programme. This discourse translated poverty into a technical problem, which called for specific state interventions that were part of the institutionalised options within the development agency. As such, it depoliticised both state intervention and poverty (Ferguson 1990, 256).

Where Ferguson focused on the development industry, Scott (1998b) analysed state intervention and (failed) large-scale social engineering projects, which he claimed relied on simplifications, an unwavering faith in science and technology, an authoritarian state, and a weak civil society. Here, especially the first is significant for understanding the role of expert knowledge in state planning. Scott describes the process through which the state, in order to control and plan, simplifies or schematises a complex reality. He argued that the state can only intervene when a phenomenon is made legible, and that the language used in the simplification process signals the objective of the state (Scott 1998a). For instance, the replacement of 'nature' with 'natural resources' illustrates a purely utilitarian, and possibly neoliberal, vision. Similar to Ferguson, Scott shows that the way in which a problem is defined matters, and that this problematisation often reflects the objectives and capabilities of the intervener.

Although in different settings and with different emphases, Ferguson and Scott both show how technical experts are powerful in defining problems, which are often in line with the solutions they can offer and the interests they have. More recently, Li build on the work of Ferguson and Scott, and identified two necessary, interlinked processes for a government's or development agency's 'will to improve' to be translated into interventions: problematisation and 'rendering technical' (Li 2007a, 7). After identifying a problem in society, 'an arena of intervention must be bounded, mapped, characterised, and documented; the relevant forces and relations must be identified; and a narrative must be devised connecting the proposed intervention to the problem it will solve' (Li 2007b, 126). In other words, the problem is rendered technical, and thereby becomes apolitical.

The processes described by Ferguson, Scott and Li emphasise again that modernity, modernisation and their legacy of technological optimism and Western-centred ideas of progress have far-reaching implications for current development interventions by both governments and donors in the Global South. In this thesis, I discuss farmer-led irrigation development and state responses to farmers' irrigation initiatives within this framework, and propose a new way of looking at current irrigation development and irrigation modernisation efforts. To do this, I first elaborate upon the common understanding of irrigation development and irrigation modernisation, in the way they are often rendered technical. I then propose the hydrosocial cycle and waterscape as a way of re-politicising irrigation development by both farmers and the state. This leads me to formulate a hydrosocial interpretation of irrigation development processes, which can serve an analytical rather than a descriptive purpose.

Irrigation development and modernisation

To understand how the common interpretations of irrigation development and irrigation modernisation are linked to modernity and modernisation thinking, it is important to understand how irrigation engineering as a discipline was formed. Most irrigation engineering practices have colonial roots, with different colonial powers developing different schools of irrigation engineering (Ertsen 2007). Gilmartin (2003) describes how irrigation engineering training for British colonial engineers was increasingly based on mathematical research in the mid-19th century. Linking irrigation engineering practice to 'the international language of science' (ibid, p. 5058) brought a certain prestige to the profession, which was only increased by the mission that was at the core of irrigation engineering: ''subduing' nature, and turning its products into 'resources' that could be used for purposes of production' (ibid, p. 5058). Efficiency became a key concept in irrigation design, and the engineer's mission was to let no water run to waste. As such, irrigation engineering as a discipline

was the ultimate expression of modernity thinking. Until today, irrigation engineers are trained to design irrigation systems based on mathematical principles, to focus on preventing waste, and to optimise productivity.[5]

With irrigation historically being the ultimate domain for technical experts, it is perhaps unsurprising that the approach to irrigation modernisation and irrigation development has been primarily an apolitical one. So far, irrigation modernisation studies for instance, have mainly been conducted by environmental and agricultural scientists, with scholarly articles being published in journals such as *Agricultural Water Management* and *Irrigation and Drainage*. The authors of these articles have approached irrigation modernisation as a technical process that often does not even need to be defined. It is implicitly equated with replacing 'traditional' canals with 'modern' sprinkler or drip irrigation systems (Albiac, Playán, and Martínez 2007; Al-Said et al. 2012; Daccache et al. 2014; Jiménez-Aguirre, Isidoro, and Usón 2018; Lecina et al. 2010; Zapata et al. 2017) or lining existing earthen canals (Govindasamy 1991; Govindasamy and Balasubramanian 1990). Those few scholars that do define irrigation modernisation, agree that it concerns the upgrading of technology and managerial systems in a specific scheme, in order to increase its efficiency and productivity (Burt 2013; Plusquellec 2009).

The motives behind these 'upgrades', or behind formally designed new schemes, are rarely challenged, as it is generally agreed that the introduction of 'modern' irrigation technologies will lead to high water use efficiency and agricultural productivity. This technological understanding excludes other motives, such as the power of the 'aesthetics of modernity' (Scott 1998b, 185): the visual appeal that modern symbols (such as drip irrigation or lined canals) have for their association with prosperity and success. Irrigation modernisation, as well as 'modern' irrigation, although never explicitly mentioned in any of the definitions, excludes 'traditional' or indigenous irrigation initiatives as possible carriers of progress. Furthermore, by using irrigation in the Global North as a reference point for successful irrigation, the Global south is excluded as a source of irrigation expertise. This is even more problematic as there are increasing doubts as to whether current irrigation modernisation interventions actually have the desired results in terms of raising productivity

[5] An example is the book that was developed for teaching irrigation engineering at the Agricultural and Biosystems Engineering Department at the University of Arizona (Waller and Yitayew 2016). The first sentence of the introduction states: 'Irrigation engineering is the analysis and design of systems that *optimally* supply *the right amount* of water to the soil at *the right time* to meet the needs of the plant system' (p.1, emphasis added). It continues to say that the 'design of irrigation and subsurface drainage systems involves the application of *engineering*, *biology*, and *soil science* in both synthesis and analysis methods of problem solving' (p.1, emphasis added).

and efficiency (Machibya and Mdemu 2005; Van der Kooij et al. 2017), and there is ample evidence that past 'modern' schemes have failed to achieve their objectives (Diemer and Vincent 1992; Moris and Thom 1990).

To overcome the descriptive nature of irrigation modernisation, and more broadly irrigation development, as a primarily technical (and possibly institutional) intervention, I reconceptualise irrigation development as a purposeful intervention in both social and hydraulic processes, which reflects and shapes the power relations between different social actors. To do this, I build on the hydrosocial cycle and waterscape concepts.

Hydrosocial cycle and waterscape

The hydrosocial cycle is a concept that aims to emphasise the social aspects of the more common hydrological cycle. Developed primarily between 2009 and 2014, it stems from a critique on water being seen as a resource, as something natural, as neutral. It has its roots in both political ecology and social studies of science (Bouleau 2014), and as such scholars engaging with the hydrosocial cycle have had varied theoretical backgrounds. The majority of contributions draw more heavily on political ecology, with a focus on power relations around water access and the production of knowledge (e.g. Budds, Linton, and McDonnell 2014; Budds 2009; Linton 2014). However, there are also clear references made to the importance of Latour's statements on modernity and the nature/culture divide (Bouleau 2014; Banister and Widdifield 2014; Schmidt 2014), as well as to elements of actor-network theory (Boelens 2014; Banister 2014; Bourblanc and Blanchon 2014). As such, the hydrosocial cycle combines elements of theoretical fields which are often deemed incompatible. The uniting objective is to show that water is neither social nor natural, but rather a hybrid (Schmidt 2014). In other words, the hydrosocial cycle is 'a socio-natural process by which water and society make and remake each other over space and time' (Linton and Budds 2013, 7). Water as a substance interacts with society and technology through a dialectical process in which one shapes the other. As a result of these these interactions water gets different meanings; it is 'produced as a particular 'water', materially and discursively, and within specific moments, contexts and relations' (Budds, Linton, and McDonnell 2014, 167). Barnes (2014) for instance, shows how in Egypt, drainage water goes from being a waste product to being a valuable resource as a result of the interactions between water and society. These interactions are mediated through power, which stems from technology, wealth, social relations, geographical location and water's physical characteristics.

The waterscape concept is closely related to the hydrosocial cycle, and is increasingly used by geographers to analyse water as a socio-natural construction. Swyngedouw (1999) was the first to use the concept of waterscape to mean something more than a visual of a landscape dominated by water. He

emphasised the hybrid character of 'the water landscape, or 'waterscape'' in Spain, thereby giving the word a broader meaning. Although he did not elaborate explicitly on the concept in his first article, it is clear that he sees the waterscape as a socio-natural production. The concept was then taken up by others (e.g. Bouleau, 2014; Budds & Hinojosha, 2012; Molle, Foran, & Käkonen, 2009; Perreault, Wraight, & Perreault, 2012; Sultana, 2013), and used to study 'the ways in which flows of water, power and capital converge to produce uneven socioecological arrangements over space and time, the particular characteristics of which reflect the power relations that shaped their production' (Budds and Hinojosha 2012, 124). Sultana (2013) explains how the waterscape concept makes it possible 'to see the ways that water technologies and development discourses coproduce certain waterscapes' (p.340). The links with the hydrosocial cycle are obvious, and Bouleau (2014) goes as far as to say that the waterscape consists of the 'geographical temporary outcomes' (p.249) of the hydrosocial cycle processes.

Inspired by the concepts described above, I understand irrigation as a phenomenon in which social actors, technology, fields, crops, and water interact and shape each other, thus conceptualising irrigation development as a purposeful reconfiguration of the elements of the hydrosocial cycle, which reflects and shapes the power relations between different social actors. In the next section, I elaborate how this understanding of irrigation supports a more critical conceptualisation of irrigation development by both farmers and the state.

Re-politicising irrigation development

In this thesis, I discuss two main types of irrigation development: irrigation development initiated by the state and irrigation development initiated by farmers. Within an engineering paradigm, both processes are often reduced to technical matters of productivity, efficiency, technology, and economic returns. However, as I have argued previously, dominant policy perceptions of farmers' irrigation initiatives are primarily driven by modernisation thinking, which excludes them a priori as a possible model for irrigation development. To make this visible and explicit, and to re-politicise irrigation development, I draw on my conceptualisation of irrigation development as a hydrosocial process that reflects and shapes power relations. I see state- and farmer-initiated irrigation development as similar hydrosocial processes, which are justified and supported by different actors and narratives, and mobilise different kinds of knowledge and/or technologies.

Budds and Hinojosha (2012), as well as Sultana (2013) argue that power relations and development discourses are reflected in the hydrosocial configurations of the waterscape. This means that the relations between flows of

water, technology, fields, farmers, and other human and non-human actors reflect the underlying power dynamics shaping them. Many African irrigation development policies, whether aimed at developing new irrigation schemes or upgrading existing ones, are characterised by their desire to modernise irrigation or the agricultural sector as a whole, which is reflected in current and past irrigation interventions. When it comes to defining successful irrigation, the societal norms on what kind of technologies, knowledge and actors are relevant for irrigation development are still influenced by the historical trajectory of modernity and modernisation, and formal scientific expertise is still privileged over other types of knowledge. In other words, particular types of irrigation waterscapes are considered desirable through water's interactions with other specific, modern elements of the hydrosocial cycle: sprinklers, drip kits, lined canals, engineering formulas, hydrological studies, formal experts and government planners. As such, interventions such as the construction of infrastructure, institutional reform and/or cost recovery measures are not neutral, but political, and reflect a modernist development discourse which has its roots in colonial times and continues to be a determining force in our world today. Framing current irrigation planning in Tanzania as part of a modernisation paradigm explains the state's attitude towards 'traditional', non-scientific irrigation initiatives by farmers. It also helps to explain how interventions are depoliticised, and how farmers are co-opted in the development and modernisation narrative.

Farmers' irrigation initiatives similarly re-order elements of the hydrosocial cycle, but are driven by farmers rather than the state. Woodhouse et al. (2017) capture this in the concept of 'farmer-led irrigation development', which refers to 'a process where farmers assume a driving role in improving their water use for agriculture by bringing about changes in knowledge production, technology use, investment patterns and market linkages, and the governance of land and water' (Woodhouse et al. 2017, 216). By focussing on the actual hydrosocial processes of irrigation development, the farmer-led irrigation development concept explicitly provides the opportunity to move beyond the modernisation discourses dominating debates on African irrigation, and to open up for different configurations of technologies, knowledge and social actors.

Although farmers have a driving role, they are not the only social actors part of the hydrosocial cycle resulting in waterscapes characterised by farmers' irrigation initiatives. Based on an analysis of a variety of farmers' irrigation initiatives, Woodhouse et al. (2017) conclude that farmers do not act independently or in isolation, but operate in a wider network of state and non-state actors, and respond to changes in their socio-economic environment. This leads the authors to call for more research on the ways in which farmers interact with external agencies and how this influences irrigation development. They emphasise that the state should not be considered as a single actor, but rather as made up of different 'policy domains' (ibid, p. 225) with different

objectives and different responses to farmers' irrigation initiatives. In this case for instance, the Zonal Irrigation Unit and Pangani Basin Water Office engage with irrigation development and water management respectively, and can therefore be expected to respond differently to farmers developing irrigation.

In this thesis, I see the state's modernisation efforts and farmers' irrigation initiatives as outcomes of similar hydrosocial processes, but reflecting specific development discourses. I use this conceptualisation to understand the interactions between farmers and the state as a political process, in which different norms and ideas on irrigation development merge and collide. While doing this, I pay specific attention to which types of knowledge, technologies and actors are promoted within irrigation development initiatives, and how this reflects or challenges modernisation thinking. In addition, my understanding of irrigation development as a hydrosocial process shapes the methodology of this research, and has inspired a multi-method approach in which social, natural, technological and discursive elements are studied simultaneously.

Research questions

As mentioned before, the aim of this thesis is to problematise the narrow notion of farmers' irrigation initiatives that exists in Tanzania specifically, and in sub-Saharan Africa as a whole. In addition, I aim to explore how underlying ideas of modernity/modernisation influence current policies and interactions between farmers and the state in the field of irrigation development, and how this influences the development trajectories of farmers' irrigation initiatives. Ultimately, I aim to contribute to the debate on irrigation development in Africa. To do this, and based on the concepts discussed in the previous section, I formulate the following research questions:

1. How do ideas of modernity and modernisation influence the state's engagement with farmer-led irrigation development, and how does this shape farmers' irrigation initiatives?
2. How do farmer-led irrigation development in the Lower Moshi area and Tanzanian irrigation policies relate to each other?
3. What are the implications of the Tanzanian case for understanding the role of African irrigation policies, on paper and in practice, with regard to stimulating irrigation development in sub-Saharan Africa?

Although the emphasis in each of the three articles is on one or two research questions, I draw on all articles to answer the different research questions in the conclusion. The third research question positions this study within the broader debate on irrigation development in Africa, and is answered by reflecting on the results of this entire research. In the following sections I will first give some background information on the research context, summarising in part what is also written in the articles. Continuing with the methodology, I explain how I conducted this research and why, and reflect on how my own positionality as a researcher has shaped this study. After a summary of the three articles, I conclude by answering the research questions posted above.

Irrigation development in the Lower Moshi area

In this section, I first introduce the Lower Moshi area which is the focus of this research. I then quickly review the main acts and policies meant to guide irrigation development, as well as the formal institutional set-up for irrigation development in the research area. A more thorough analysis of Tanzanian irrigation policy and intervention history in the Lower Moshi area can be found in article 1.

The research area

This research focuses on the Lower Moshi area, and specifically on Kahe ward, in the Kilimanjaro Region in northern Tanzania (Figure 1).

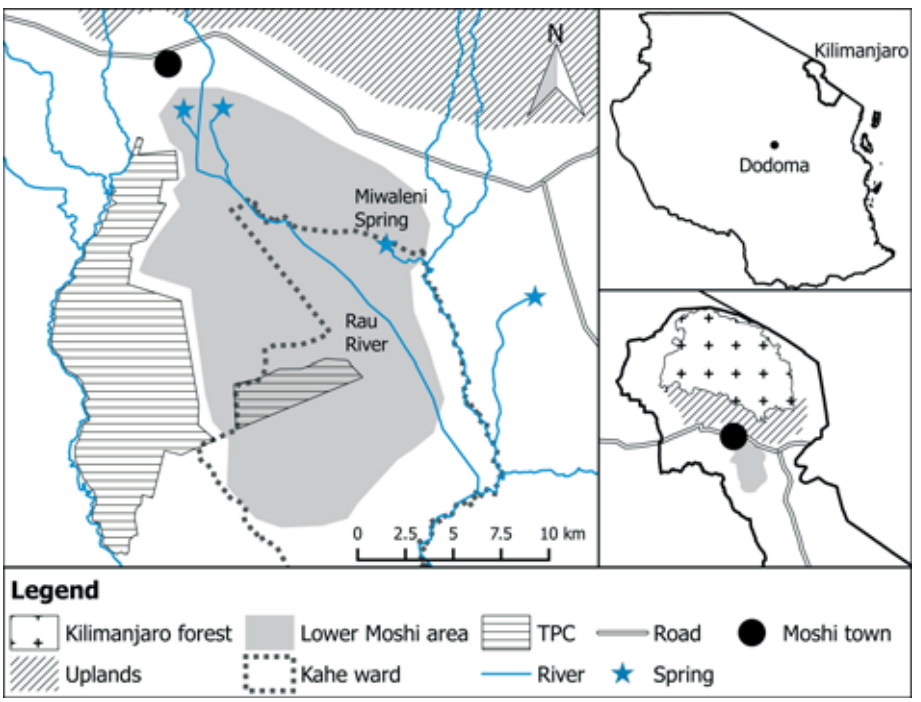

Figure 1 - Location of the Lower Moshi area and Kahe ward

The area is part of the southern lowlands of Mount Kilimanjaro, with Kahe ward located at 700 meters above mean sea level (Rudengren 1981). The Kahe villages of Miwaleni, Kisangesangeni, Oria, Ngasinyi A and B and Mawala have a combined population of about 19,000 (NBS 2013). The main water sources are the Rau River and the Miwaleni spring. The Miwaleni spring has a continuous discharge of about 4 m^3/s, and the Rau River discharge fluctuates throughout the year due to periodic rainfall and upstream abstractions. Kahe ward only receives water from the Rau River during the main rainy season when flood waters inundate part of the area. Rainfall patterns are generally bimodal, with a long rainy season from March to May and a short rainy season between October and December. The amount of rain varies drastically with altitude: annual average rainfall in the highlands can be as much as 2000 mm, while in the plains precipitation is less than 500 mm (IUCN 2003; Mkhandi and Ngana 2001; Turpie, Ngaga, and Karanja 2003). In Kahe ward, average annual rainfall over the period 1990-2012 was 365 mm (PBWO 2013). However, speaking in terms of annual average rainfall hides the highly variable rainfall patterns. Both quantity and timing vary from year to year and are rather unpredictable. This has large implications for agriculture, and in combination with declining rains (Hemp 2005) it has made irrigation a precondition for secure crop production in the Lower Moshi area.

I purposefully selected the Lower Moshi area because of its dynamic irrigation history, during which both the state and farmers developed different kinds of irrigation. As an area, Lower Moshi can be said to represent most aspects of irrigation development and irrigation history in the country: it encompasses part of the public Lower Moshi Irrigation Scheme (LMIS), shallow wells dug and used by farmers, several farmer-initiated rice irrigation areas, and lift irrigation with pumps from canals and rivers. Furthermore, Kahe farmers share water sources with the commercial sugar estate of the Tanganyika Planting Company and the whole area is downstream of (partially pre-colonial) farmer-built irrigation canals in the uplands of Mount Kilimanjaro. In fact, irrigation development in the Lower Moshi area is inextricably linked to these upstream irrigation systems on the mountain slopes. This is not only due to its close proximity and the migration of people from the highland to the lowland areas, but also because, as mentioned, the irrigation systems on Mount Kilimanjaro have shaped national irrigation policies for decades. For this reason, the upland systems are included in the description of (historical) irrigation activities in the study area in the next paragraphs (for a rough timeline of irrigation development activities, see Figure 2).

The farmer-built canals on Mount Kilimanjaro and the neighbouring Mount Meru together irrigated more than 60% of the registered irrigated area in Tanzania in 2002[6] (URT/Nippon Koei 2002, 5–3), and are the model for the 'traditional irrigation' policy category described in the introduction of this thesis. Some of these systems date back to precolonial times (Stump and Tagseth 2009), and are still used for irrigation today. Water is diverted from perennial rivers and continues through a network of earthen irrigation canals,[7] with each canal system irrigating hundreds of farms. Along the way, water leaks and seeps, often to be used downstream through springs or pumped groundwater. Farmers organise to rebuild the intake structures regularly, as many are made of branches and stones and get washed away by the river after heavy rains. Irrigators contribute labour to clean the canals to facilitate the flow of water. In times of water scarcity, farmers can put in a request to receive water, on basis of which a canal committee draws up a schedule. This same committee collects the money needed for maintenance through annual fees paid by each water user. Each farmer has to become a member of the canal if he or she wants to use water. There is a set of rules to follow and punishments for irrigators who violate those rules. Fines might have once been demanded in kind (a goat, sheep, local brew, etc.), but now monetary compensation is more common. Farmers generally own anything from 0.1-5 hectares, with downstream plots generally being bigger, while upstream plots are smaller. Typically, a mixture of crops is grown: coffee, bananas, maize, beans and vegetables. Part of the produce is sold in the market, and much of it is for home consumption.

In the lowlands, similar irrigation systems only started in the first half of the 20th century, and during that time the area was only sparsely populated (Teale and Gillman 1935; Aerial photos 1962). Lack of water and the prevalence of malaria and sleeping sickness made the lowlands an unattractive place to settle.[8] Eventually however, as the population on the mountain slopes grew,

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[6] This figure from the Study on the National Irrigation Master Plan (SNIMP) from 2002 was compiled from data collected in Arusha, Kilimanjaro and Tanga regions by the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP), and data collected by the SNIMP team in the remaining regions. As the RBMSIIP had a clear smallholder focus, and covered less area, it is likely that the area covered by this survey recognised a larger share of farmers' irrigation initiatives. However, when comparing the 10 case studies of farmer-led irrigation development from the SAFI project with the list of surveyed schemes in the SNIMP, the schemes in the northern regions are recognised equally to those in the rest of the country (50% of schemes are registered). As only half of farmers' irrigation initiatives are registered, the total share of irrigation developed by farmers is likely to be even larger than what is recorded in the SNIMP.

[7] This is a rather general description of farmers' irrigation initiatives on Kilimanjaro and Meru. The description is based on my own experience and research in the Mount Meru area (de Bont et al. 2016). For similar descriptions, see Gillingham (1999); Tagseth (2010; 2008b; 2008a); and Komakech (2012; 2013).

[8] Tanzania National Archives, Dar es Salaam: Acc. No. 5, file no. 24/17. 1947-1950. File title: Development of lower areas. Meeting 18th October, 1948

people moved down, settled, and expanded the canal systems from the highlands to the lowlands. The colonial government attempted to speed this up by creating two irrigation settlement schemes on the Rau River in the early 1950s (de Bont 2018c, this thesis), but these failed and have had no lasting impact. Farmers did eventually develop irrigation along Rau River, with some canals starting as far downstream as Kahe ward (Beez 2005; Water Master Plan Team 1977). During the 1960s, the newly independent government also started to explore options for developing irrigation in the Lower Moshi area, in an attempt to boost agricultural productivity. Two schemes were proposed: one using water from the Miwaleni Spring and one relying on groundwater in the area around the spring. The first was initially planned as a 3,000 hectare irrigation scheme (FAO 1969), in which smallholder farmers were meant to grow cash, staple or fibre crops. The project was eventually turned into a commercial government estate, where the fibre crop kenaf was cultivated (Boeree 1972). After it failed due to soil salinity problems, the land was first given to the National Food and Agricultural Cooperative (NAFCO) for cattle keeping, and later to the Tanganyika Planting Company (TPC) for sugar cultivation. Until today the large canal leading to the sugar estate is known as the NAFCO canal, and supplies water to TPC and downstream rice farmers in the Mawala irrigation scheme. The second irrigation scheme, the Miwaleni groundwater scheme, was meant to rely on deep boreholes in the area north of the spring, after which water would be distributed by gravity (FAO 1969). The scheme never made it beyond the pilot phase, but remnants of it can still be seen today.

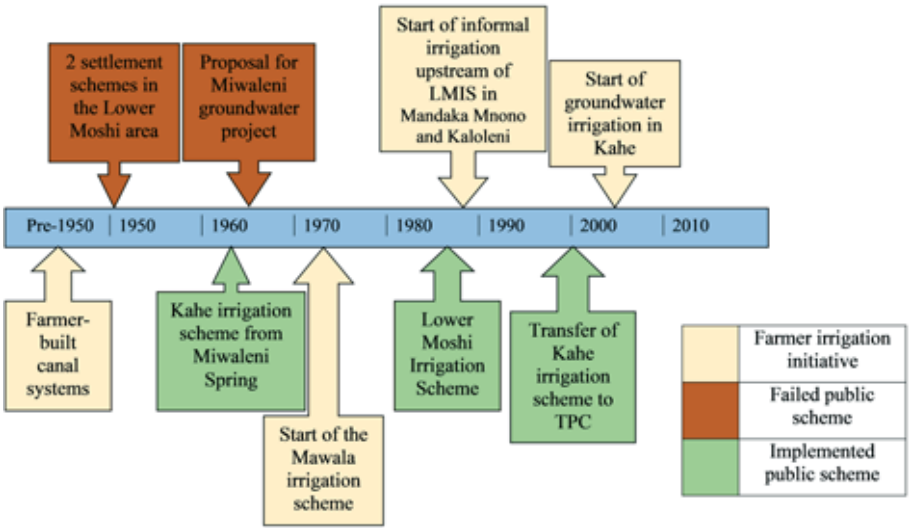

Figure 2 - Timeline of irrigation development activities in the Lower Moshi area

Upstream of the Kahe area, other farmers also continued to develop agriculture and Rau River was increasingly tapped for domestic use and irrigation.

In 1983, construction began on the Lower Moshi Irrigation Scheme (LMIS) and the 1,100 hectare smallholder rice cultivation scheme was completed in 1986. One of the major innovations in the scheme was the cultivation of high yielding rice varieties. The use of these varieties was also adopted by farmers in the Mandaka Mnono and Kaloleni areas upstream of the LMIS, and irrigated agriculture expanded and intensified in those locations. Diversions to those new irrigation areas (considered informal or even illegal by the government) caused water shortage in the LMIS. The combined water use by the LMIS and the informal rice areas led to the drying up of Rau River downstream. From the mid-1980s, river water only reached the canals in Kahe during the rainy season.

The lack of surface water led to a strong reduction in irrigation activities and farmers practised rain-fed farming from the mid-1980s. As time went by, rainfall started to decline. By the early 2000s, farmers found that rainfall in average years was no longer sufficient to grow a single maize crop. In present day, smallholder farmers rely on the NAFCO canal for irrigating paddy rice in the Mawala irrigation scheme (de Bont and Veldwisch 2018, this thesis), use pumps to lift water from that same canal for maize or vegetable cultivation or pump water from shallow wells that they have dug by hand (de Bont, Komakech, and Veldwisch 2018, this thesis). In some places, farmers still divert flood water from Rau River, but only during the rainy season. Especially the use of groundwater has given an enormous boost to the economic activity in the area, with external actors coming in to grow onions and tomatoes for Tanzanian and Kenyan markets.

The landscape resulting from the irrigation initiatives mentioned above is reflected in Figure 3 and Figure 4.

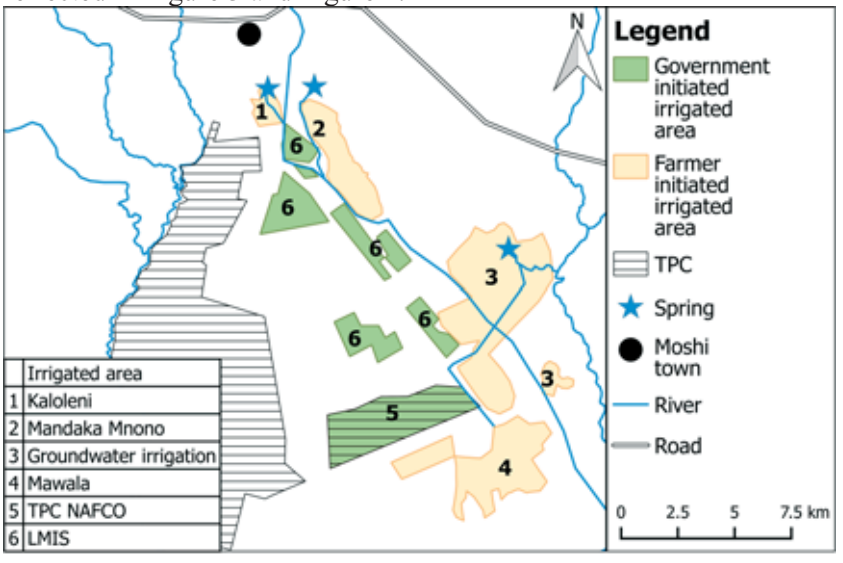

Figure 3 – Irrigated areas initiated by farmers and the state in the Lower Moshi area

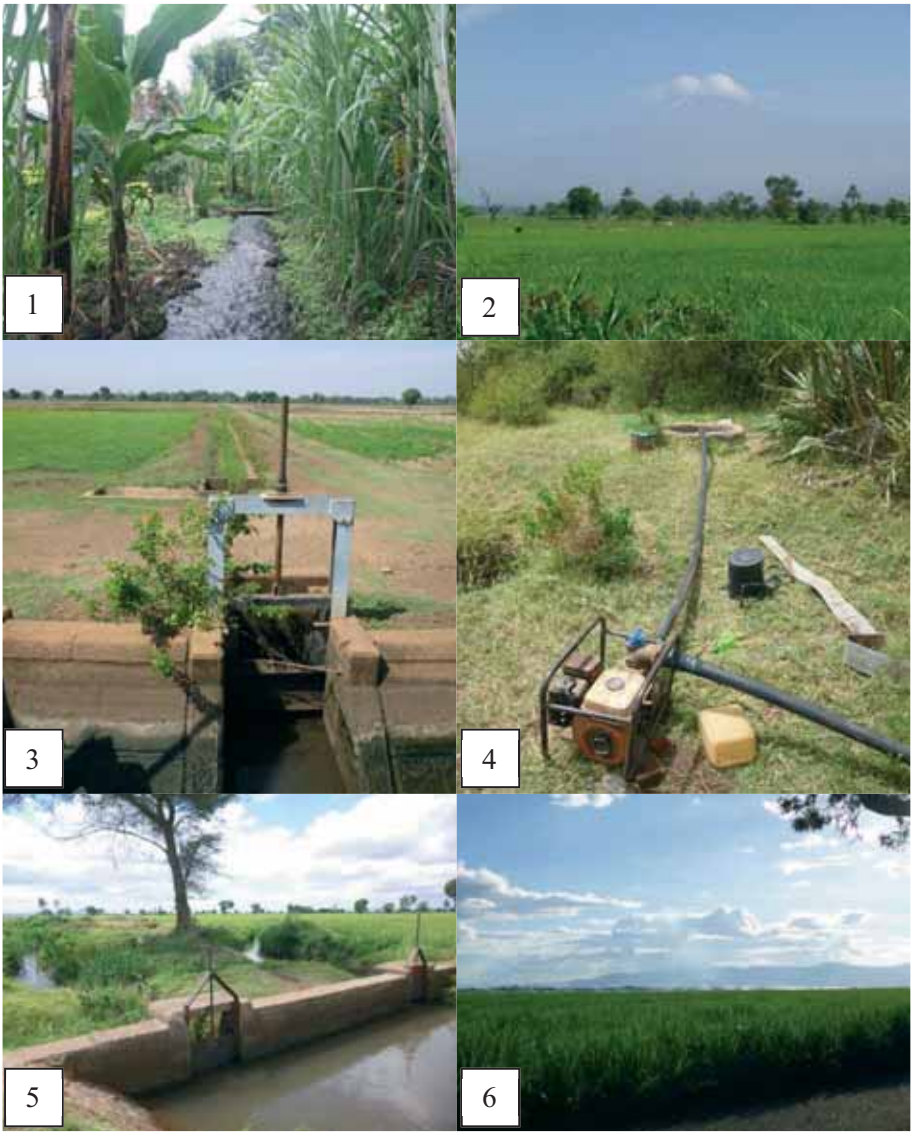

Figure 4 – Irrigation types in the Lower Moshi area: 1. Canal in the uplands; 2. Mandaka Mnono rice area; 3. Lower Moshi Irrigation Scheme; 4. Pump and well in Kahe ward; 5. 'Improved' intakes in Mawala irrigation scheme, with earthen canals; 6. Sugarcane estate of TPC-NAFCO (Photo credit: the author)

Irrigation acts and policies

Policy implementation is not a linear process in which paper policy is transformed into real-world outcomes, but rather an interactive one, which can lead to a variety of outcomes as policy elites and implementers try to respond to societal reactions to policy implementation (Thomas and Grindle 1990, 1165). As such policy is transformed and reinterpreted during the implementation process (Long 2001). For African irrigation specifically, decades of disparity between paper irrigation policy and policy in practice illustrate that policy narratives and implementation cannot be equated. However, paper policy does influence the arena within farmers and the state interact, and reflects the attitude of the state towards irrigation planning. In the following paragraphs, I therefore discuss the most important acts and policies, and show how they reflect key elements of modernisation thinking, before shortly outlining the processes of irrigation development policy implementation and the most important actors at the local level.

There are several acts and policies that are relevant for irrigation development in Tanzania. The 2004 Environmental Management Act for instance, states that an environmental impact assessment should be done before any type of irrigation is developed (URT 2004). In addition, the 2009 Water Resources Management Act outlines the requirements and processes for obtaining a water use permit, which is mandatory for any water user in Tanzania (URT 2009). The main act governing irrigation however, is the 2013 National Irrigation Act (NIA). When it comes to policies, the National Agriculture Policy (URT 2013a) and the Water Policy (URT 2002) both mention irrigation and its importance. They primarily follow the existing irrigation policies however: the National Irrigation Policy (NIP) (URT 2010) and the National Irrigation Development Strategy (NIDS) (URT 2016). I will therefore focus on the NIA, NIP and NIDS, which are the latest documents outlining the irrigation development strategy for Tanzania.

During the time the irrigation act, policy and development strategy were published, irrigation was alternately the responsibility of the Ministry of Agriculture, Food Security and Cooperatives (2006-2008; 2010-2012) and the Ministry of Water and Irrigation (2008-2010; 2012-ongoing). All three documents however, were published under the Ministry of Water and Irrigation. There was no explicit external support in drafting the documents, and I take them to reflect the current formal attitude of the Tanzanian state towards irrigation development. It should be noted however, that both the policy and development strategy strongly reflect the 2002 Study on the National Irrigation Master Plan, which was executed by two Japanese consultancy firms (Nippon Giken Inc. and Nippon Koei Ltd.) and supported by the Japan International Cooperation Agency (JICA). This emphasises that, although the documents discussed here are essentially Tanzanian, they were not written in isolation from the international discourse on irrigation development.

The National Irrigation Act was written 'with a view to ironing out challenges in the irrigation sector' (URT 2013b, 51), one of which was the 'lack of knowledge and awareness on the part of individuals that led to the poor performance in the management of irrigation works' (ibid, p.51). The act provides for the establishment of a National Irrigation Commission (NIC) to govern the development of irrigation and aims to ensure the implementation of the NIP and NIDS. The establishment of the NIC formally vests the power to develop irrigation in the state. The NIC is meant to 'coordinate *all* interventions in irrigation sector conducted by the development partners *and other stakeholders*' (ibid, p.12, emphasis added) and 'no irrigation works shall be constructed until the proposed scheme of the undertaking has been submitted to the Commission for approval and such project is subjected to the Environmental Impact Assessment as provided for under the Environmental Management Act' (ibid, p.22). In addition to the environmental impact assessment, an applicant is required to provide a design report, a list of drawings, a bill of quantities, and a water use permit. These requirements, for which no exceptions are made in the law, make it virtually impossible for farmers to legally develop irrigation. It is unlikely that this law will be enforced rigorously when it comes to smallholder farmers, but it illustrates how the Tanzanian government sees farmers' role in irrigation development. During this research, I did not encounter any expressions of the restrictive nature of the irrigation act, although local government authorities did feel that farmers should first consult them before developing any irrigation infrastructure.

The 2010 National Irrigation Policy, together with the irrigation development strategy, informs the national budget and provides guidelines for national, regional and district government authorities. The NIP has the objective to 'ensure sustainable availability of irrigation water and its efficient use for enhanced crop production, productivity and profitability that will contribute to food security and poverty reduction' (URT 2010, 13). In the rest of the text, it becomes clear what the Tanzanian government expects efficient, productive and profitable irrigated agriculture is to look like. The four recognised categories are traditional irrigation, rain water harvesting irrigation schemes, improved irrigation schemes, and large commercial irrigated farms. Traditional irrigation systems, those made by farmers, are linked to the policy objective to 'improve both the hardware and software aspects' (ibid, p.15) so that they can become 'improved traditional irrigation schemes', which 'have received interventions by an external agency' (ibid, p.15). There is no mentioning of farmers' initiatives to be recognised as improved or adequate without external intervention. This again reflects the conviction that irrigation planning is a task of the state. In addition, the mentioning of software and hardware shows that state intervention is not just about changing infrastructure, but also about changing (and controlling) the management structures of farmers' irrigation initiatives.

The irrigation policy also states the importance of a demand-driven, participatory approach in developing new irrigation schemes. However, it seems that this is primarily a tool for successful implementation, rather than an emancipatory process: 'Participatory approach techniques have to be applied in order to inculcate farmers' sense of ownership, commitment and responsibility for their irrigation schemes' (URT 2010, 19). Article 3 in this thesis elaborates further on the process and meaning of demand-driven irrigation development in Tanzania.

The 2016 National Irrigation Development Strategy covers the period between 2010 and 2025 and aims to 'provide a framework through which the objectives and policy statements of the National Irrigation Policy, 2010 shall be implemented by all relevant institutions and stakeholders to attain the vision and mission stated in the policy' (URT 2016, 14). As such, it echoes and reinforces much of the irrigation policy. In addition, it reaffirms the position of the National Irrigation Commission and outlines its proposed organisational structure and relationship to lower level irrigation authorities. Another new aspect is the objective to expand the 'developed area for irrigation' to one million hectares by 2016 (URT 2016, 14). This figure does not include the areas irrigated by 'traditional' (farmer-initiated) irrigation, unless they are 'improved' by external intervention. The national irrigation strategy is essentially the operationalisation of the national irrigation policy. It incorporates aspects of the irrigation act and confirms the state's earlier attitude towards farmers' irrigation initiatives, emphasising once again the importance of formal engineering and the importance of external intervention for irrigation modernisation and irrigation development.

Irrigation authorities and responsibilities

The main authorities involved in irrigation development policy implementation in the Lower Moshi area are the Kilimanjaro Zonal Irrigation Unit, Moshi Rural District Office, and the Pangani Basin Water Office. Here I describe the tasks and responsibilities of each authority, and explain what role they play in the policy implementation process.

Tanzania is divided in seven irrigation zones: Central, Mwanza, Mbeya, Tabora, Mtwara, Morogoro, and Kilimanjaro. Each zone has its own Zonal Irrigation Unit (ZIU), which is responsible for the identification, design and supervision of irrigation projects. In the study area, this is the Kilimanjaro ZIU. With the devolution of power to the District Offices (DO), the greatest responsibility for agricultural development and irrigation planning lies with the DO, in this case the Moshi Rural District Office. The ZIU primarily functions as a consultant to the DO and gets hired to design and supervise irrigation interventions alongside the district irrigation engineer. Actual construction can either be done by an external contractor, or can be directly supervised by

the ZIU or the DO. In the study area, the District Irrigation Engineer expressed a preference for hiring an external engineering firm.

Funding for irrigation development projects is either provided by the national government or by an external donor. An example of the latter is the 'Small Scale Irrigation Development Project', funded by JICA and implemented by the ZIU and the DO (JICA 2013). In this project, several irrigation canals dug by farmers were lined and intakes were reconstructed. This is the latest of similar projects in the study area (URT 2001; World Bank 1996). The River Basin Management and Smallholder Irrigation Improvement Project for instance, ran from 1996 to 2004 and engaged with smallholder farmers to improve 5,000 hectares of traditional irrigation and set up 19 irrigation organisations in the Rufiji and Pangani basins (World Bank 2004). This kind of projects illustrates how the Tanzanian state does recognise and engage with (some[9]) farmers' irrigation initiatives, unlike neighbouring countries, but also has a strong modernisation and formalisation mind-set that drives interventions. Both projects mentioned above claim to have had a participatory and demand driven approach in developing infrastructure, and were therefore in line with both the irrigation policy and development strategy.

The Pangani Basin Water Office (PBWO) is the river basin authority which is in charge of managing all water abstractions within the Pangani basin, of which the Lower Moshi area is part. Set up in 1991 as the first river basin office in the country, the PBWO was expected to control water use and secure flows for downstream formal irrigation projects in Lower Moshi and Ndungu, as well as for the downstream hydropower plants at Nyumba ya Mungu and Pangani Falls (van Koppen et al. 2016). This was to be achieved by making all water users apply for water use permits, which gave no guarantees in terms of water abstractions, but did obligate water users to pay fees (Komakech et al. 2011). As most smallholder farmers did not have a permit, their water use was deemed illegal. The formalisation of water rights overrode the existing institutional set-up of customary water rights, leading to the dispossession of farmers' water rights on paper, while benefiting large-scale users (van Koppen et al. 2016). Similar processes have been observed in other African countries where formal water permit systems have been introduced, as structural inequalities determined water users' ability to obtain a permit, and larger and richer water users were better able to navigate bureaucratic systems (van Koppen 2007). In spite of formalisation efforts, customary water rights are still critically important in the Pangani basin (Komakech and Van der Zaag 2011; Komakech, Condon, and Van der Zaag 2012; de Bont et al. 2016; Komakech et al. 2012). This, combined with the inability of the PBWO to

[9] Those that are recognised and engaged with are primarily schemes that fit the standardised idea of traditional irrigation: earthen canals diverting water from small streams or rivers (de Bont, Komakech, and Veldwisch 2018, this thesis).

monitor and enforce water abstractions, makes that the dispossession mentioned above does not fully materialise.

Currently, having a water use permit is a prerequisite for receiving state support for irrigation development. However, upgrading irrigation technology and formalising irrigation institutions often go hand in hand. As such, although the PBWO, ZIU and DO are positioned within different policy domains, they are drawn together in implementing projects under the irrigation policy. In this thesis, I engage with two cases of farmer-led irrigation development and show how the paper policy materialises in practice as the result of interactions between farmers, the ZIU, the PBWO and the DO.

Methodology

In this section I describe my research strategy and provide a detailed description of how I implemented this strategy. I start by outlining the study design and motivate my choice for the case studies I selected. I continue by touching upon the research collaborations that were part of this study, and then describe and reflect on the different methods I used. After explaining how I analysed my data, I reflect on my own positionality within this research and discuss how I shared research results with participants as part of honouring the reciprocal relationship that I believe should be at the heart of any ethical research.

Study design

This thesis is based on three case studies, which overlap in time and geographical area, but are all part of the geographical and institutional context described in the previous sections (Figure 5). Case studies are generally applied to contemporary phenomena (Yin 1994), but can also be used to describe a phenomenon over time (Hancock and Algozzine 2011). Similarly to a contemporary case study, a historical case study aims to explain how and why things happen(ed) and includes not only archival research but also interviews and observations (idem).

The first case study is a historical case study of the Lower Moshi area, which is used to analyse the history of public irrigation development in Tanzania between 1935 and 2018. As explained previously, I purposefully selected this area as a case because of the many types of irrigation within its boundaries and the different development processes underlying these irrigation activities. Apart from this diversity, I also see an opportunity to expand the geographical area covered by researchers studying (farmer-led) irrigation in northern Tanzania: there has been a strong emphasis on canal systems on mountain slopes (Tagseth 2008a; Stump and Tagseth 2009; Gillingham 1999; Grove 1993; Huijzendveld 2008; Mul et al. 2011; Hakansson 1995), while irrigation in the plains is much less studied (for an exception, see Beez 2005). Data collection for this case consisted primarily of archival research in Tanzania and the United Kingdom in 2015, supplemented by interviews and observations. The collected material (mostly reports, plans and maps) feeds into Article 1.

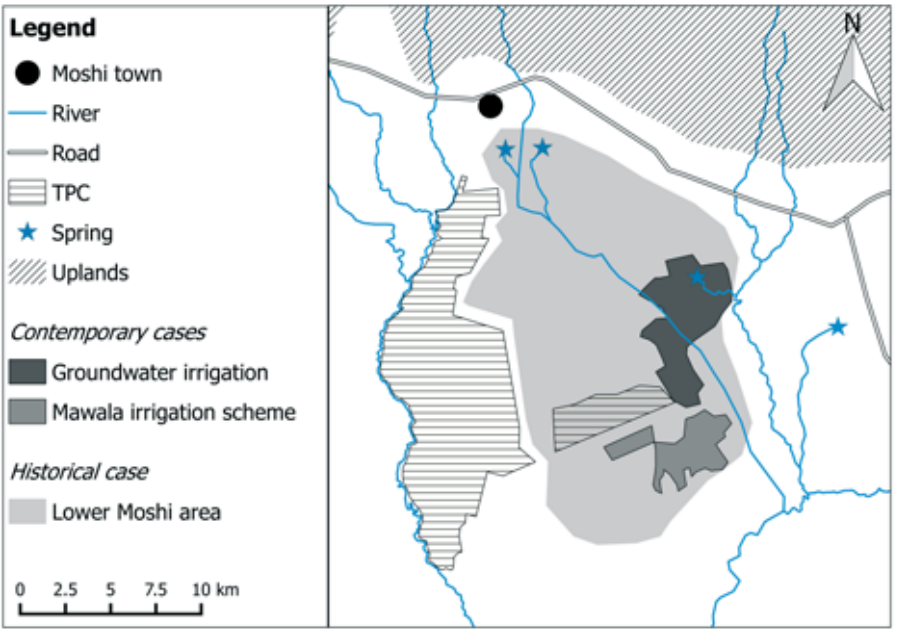

Figure 5 - Map of the case study areas (note: Lower Moshi area is not the same as the Lower Moshi Irrigation Scheme (LMIS), which can be seen in Figure 3).

The second and third case study are contemporary studies in Kahe ward, which is part of the Lower Moshi area. Both cases are spatially bound based on the use of irrigation technology: one consisted of those areas where farmers used shallow wells and petrol pumps for irrigation, and the other was the waterscape of the Mawala irrigation scheme. I selected the groundwater irrigation area because it is the type of irrigation that most clearly challenges the state's preconceived notions of farmers' irrigation initiatives. Local government officials do not consider groundwater to be a water source that farmers access independently, and the use of motorised pumps does not match the stereotypical idea of traditional irrigation. In addition, the area was largely ignored by the government, giving me the possibility to explore why and how farmers do or do not become the target of state intervention. The Mawala scheme was strategically selected after the zonal irrigation engineers identified it as a successful example of demand-driven participatory irrigation improvement. If the policy of demand-driven irrigation development could be challenged in a 'favourable case' (Flyvbjerg 2006, 226), it would be easier to speak to the policy at large. If not, I could use this case with high state involvement as a contrast to the other contemporary case of low state involvement and to explore what happens to a farmer-initiated and -managed scheme when farmers voluntarily engage with external actors. Data collection for these contemporary case studies was done over a total period of five months

through semi-structured interviews, observations, GPS mapping, walking interviews and focus groups. The multi-method approach that I have used reflects my understanding of irrigation as a continuously developing waterscape, in which human actors, infrastructure, water and fields interact. This meant looking not only at current day practices, but also the history of the area, and not only interviewing people but also actively engaging with their interactions with water flows and infrastructure through mapping and walking interviews. In addition, interviews covered social (institutional set-up, collaboration, conflict), technical (pump specifics, canal discharges, infrastructural functioning), agronomic (yields, use of agricultural inputs), as well as economic (market access, costs of farming) topics. Each contemporary case study forms the basis for an article, but both also feeds into my overall understanding of irrigation development in the Lower Moshi area, and is therefore used in Article 1.

Collaborations

During this research, I collaborated with other researchers and field assistants. Specifically, I worked together with Muthio Nzau, a junior researcher of the Studying African Farmer-led Irrigation (SAFI) project when studying the shallow well irrigation. This collaborative case study supports my own work, but is also a case within the SAFI project and led to the co-authored article 2. SAFI researchers also conducted a questionnaire in one village in Kahe ward, data of which is used in that same article. The shallow wells study was supported by field assistant Nailijwa Mkwavi, while the research in the Mawala irrigation scheme was supported by field assistant Honorata Mselle. Below, when I refer to 'we', I refer to these different research teams. The historical research was done by me alone.

Research methods

As explained above, each article is based on a variety of data, collected through various methods and at different times. Below, I elaborate on the different methods, the resulting data and the role they played in the research at large. Although I separate data collection and analysis here, in reality there was a continuous process of data collection, analysis and reflection.

Archival research

In order to analyse the history of the Tanzanian state's attitude towards irrigation planning and farmers' irrigation initiatives, and the role of modernisation

thinking in shaping this, I did archival research in several locations. Some of these archives were formal archives, but others were simply documents that were stored in local government offices.

The latter was the case for the Zonal Irrigation Unit and the Pangani Basin Water Office in Moshi. Here, I was given the freedom to go through old maps and reports, which led to some unique finds. In the process I digitised all hand-drawn maps from the 1960s in order to preserve them, and to make the results of my research efforts available for those who gave me access to the information (see also the section on reciprocity in ethical research). I returned the original and digital versions to the offices. The exercise not only gave me access to the documents, but also showed the ways in which data was stored in the two locations, and what this meant for current operations. In both locations, officials were not quite sure what was in their libraries/archives. This was especially striking because many of the current challenges and questions were actually discussed in reports dating back decades, which could have therefore informed current planning and management. During a second visit, the Zonal Irrigation Unit staff also allowed me to read and photograph all communication (letters, minutes, reports) between farmers from the Mawala irrigation scheme and government officials. This helped me to reconstruct certain events in the scheme, and to analyse the interactions between farmers and government employees, but also among farmers. This was used in article 3.

In Tanzania, I also visited the national archives in Dar es Salaam, where I read correspondence on irrigation development during British colonial times. Finally, I went to the East Africana Collection of the library of the University of Dar es Salaam and found more government-published reports and plans on irrigation and agricultural development. After this, I went to the colonial archives in Oxford and London. Apart from conducting a wide search on irrigation in Tanganyika, I also looked for specific materials referenced in documents I had already collected. At the Bodleian library in Oxford, I obtained aerial photos of my research area from 1962 and 1981, which I used to confirm some of the timelines of irrigation development that I established from interviews. The obtained documents, together with more recent online materials such as the national irrigation policy (URT 2010) and the national irrigation act (URT 2013b), are the foundation for article 1.

The formal archives I visited were colonial archives that were compiled under British colonial rule. All archives have a bias because somebody passes judgement on what written documents are to be included or excluded in the archive (Mbembe 2002). Colonial archives specifically are not only biased because most written documents were produced by the government, but also because that same government controlled what was and what was not submitted to the archive. Hamilton et al (2002) emphasise that archives should not be seen as an ‘incomplete whole’ because of this, but rather as a ‘sliver’ of reality (p. 10). To mitigate some of the biases in the official public records, they propose several methods, among which literature, landscape analysis and

oral histories. Following the warnings of both Mbembe (2002) and Hamilton et al (2002), I made sure to keep in mind how the colonial archival documents I read were produced, by whom, and what was not mentioned. The absence of farmer-led irrigation development in many colonial records for instance, clearly reflected the interests of the colonial government. I tried to use my interviews, knowledge of the current landscape and existing literature on the area to fill in some of the gaps that existed in the archives.

Mapping of irrigation infrastructure

The mapping of infrastructure had both an exploratory and deepening function in this study. Farmers' irrigation initiatives are often not, or partially, mapped by the government or other external actors, as was the case here. There was no map or record of the wells used for irrigation, and the map for the Mawala irrigation scheme missed canals that were added more recently. In the first phase of the well irrigation case, Ana Msigwa (a researcher from the Arusha-based Nelson Mandela African Institute of Science and Technology) recorded all shallow wells in Kahe ward, including their location, purpose, depth, and name of the owner. This formed the basis for the purposeful sampling of interviewees in the second stage of the study (see below). In addition, I used this data to create maps of all well locations (Article 2) and the approximate irrigated area (Article 1). In the Mawala case, we mapped all secondary canals with a handheld GPS, including observations on infrastructural features, crops, and water availability. Some of this mapping took place during walking interviews, some was done independently. These mapping exercises were used to create the maps in Article 3, to analyse the extent to which the irrigation improvement projects had actually transformed the infrastructure in the scheme, and to see what farmers' initiatives occurred alongside the government interventions.

As mentioned above, the irrigation areas I recorded were previously not, or partially, mapped by the government. Furthermore, farmers did not have access to these maps, and especially not in a way that made sense to them (too schematic, few real-world features for reference). As such, mapping these irrigation areas based on farmers' information, and making these maps available to them, had the possibility to aid farmers in getting government recognition of their irrigation initiatives and requesting support. Wainwright and Bryan (2009) and Fox et al (2008) recognise this emancipatory power of mapping, but also warn of its limits and unintended consequences. The main limit these authors identify is that by mapping their land (in this case their irrigated lands and irrigation technologies) communities are co-opted into the knowledge system of the state, which might contradict with their own understanding of space. In this case for instance, mapping the boundaries of the irrigated area in Mawala as a fixed line, ignores the dynamics in the scheme and the fact that

it is continuously expanding. There is a danger that a map of current irrigated areas will be used as a baseline to stop further expansion. Other unintended consequences are increased conflict between communities as boundaries are drawn, increased regulation and co-optation by the state, loss of indigenous conceptions of space and the privatisation of land (Fox et al. 2008; Wainwright and Bryan 2009). In my case, especially the second (increased regulation and co-optation by the state) is a real concern. What is not visible to the state, cannot be managed by the state (cf. Scott 1998a). All farmers expressed an interest in receiving government support, but making these areas visible (especially the shallow wells) can also lead to state efforts to control, tax or shut down farmers' irrigation initiatives. This is something farmers were also well aware of, and formed a concern for me as a researcher (see also the section on ethical research). However, as Fox et al (2008) explain, spatial information technology does not have 'exit rights' anymore: as it is used more and more, communities cannot escape mapping. As you cannot claim unmapped land, you cannot demand government support for irrigation in an area which is not recognised as irrigated land. As such, I endeavoured to produce maps that were in the best interests of the community, and to mitigate the negative effects of becoming visible.

Semi-structured interviews

For both contemporary case studies we conducted semi-structured interviews, which are suitable to get information on specific pre-defined topics, while leaving enough space for participants to bring up other issues (Longhurst 2010; Valentine 2005). The selection of participants in the villages was different between the two cases.

For the well irrigation case, we initially used the list of wells that was drawn up in the preliminary study to purposefully select participants for semi-structured interviews in Kahe town. We targeted those who were using their well for irrigation, while trying to interview both men and women. After this, we walked in the different parts of the villages and looked for irrigation wells. If we could not find any wells in that part of the village, we would ask people whether they knew of any wells used by them or their neighbours. For the wells we encountered, we asked the owners whether we could interview them. In the rural areas of Kisangesangeni, Miwaleni and Oria villages, it proved that almost all wells were used for irrigation. We interviewed a total of 20 women and 26 men. We interviewed people in different geographical areas in order to cover different biophysical conditions that could be expected to influence well use (groundwater table, flooding risk, soil type). Four large-scale farmers who did not reside in the study area were purposefully selected for interviews, two of which were interviewed in Moshi town while the others

were interviewed at their farm. All interviews focused on agricultural practices, irrigation history, motives for investment in irrigation, constraints to agricultural intensification, and irrigation activities.

In the Mawala irrigation scheme, we purposefully interviewed those people that were most likely to be directly involved in state irrigation improvement projects. This meant that we interviewed canal leaders (10), current and former leaders of the irrigation cooperative (4), current and former construction committee members (3), and village leaders (3). Interview topics included the history of the irrigation scheme, its current functioning, the interviewee's role in the interventions that took place, and the challenges of the scheme.

All interviews were conducted in Swahili, with the research assistant translating the questions and answers. I took notes and later elaborated these in my field notes. Each interview was preceded by an introduction of us as researchers and an explanation of the research objectives, followed by the question whether the person wanted to participate in the study. For a more extensive reflection on how my positionality influenced both people's willingness to participate and the content of their answers, see the section on reflexivity.

For both cases, we interviewed staff members of the Zonal Irrigation Unit, the Pangani Basin Water Board and the District Office. During these interviews, I either took notes or recorded and transcribed them later. The interviews were primarily held in English. The main topics were the interviewee's role in developing irrigation and his (all were men) responsibilities and daily activities; the criteria on which basis areas were chosen for irrigation intervention; his ideas on what irrigation should look like; the challenges his office faced when managing water and developing irrigation; what he thought of farmers' irrigation initiatives in the case study area; and other questions based on current events in the study area (water conflict, infrastructural projects). Due to the repeated contact, going back to 2012, I developed a good relationship with especially the ZIU and the PBWO staff. This helped in organising the repeated interviews.

Walking interviews with canal leaders

The walking interview is a mobile method where the interviewer and interviewee move through the landscape (either on a pre-defined route or spontaneously, guided by the interviewer or the interviewee) while talking (Jones et al. 2008). Different places can trigger memories, or bring up certain topics, thereby giving the researcher access to insights between place, time and people (Anderson 2004). Evans and Jones (2011) show 'that walking with interviewees generates more place-specific data than sedentary interviews (…), tend to be longer and more spatially focussed, engaging to a greater extent with features in the area under study' (p.856). Finlay and Bowman (2017), in

their study on the mobility of elderly people in urban neighbourhoods, identified benefits of the walking interview method that go beyond increased referencing to the environment. First of all, the researchers bodily experienced the challenges their interviewees faced in moving around. Secondly, interviewees were more at ease and a natural conversation developed. Finally, the power dynamic between the interviewer and the interviewee shifted, as the interviewee became the expert guide. Besides these advantages of the walking interview, there are also downsides. Recording what is being said where is not only technologically and practically complicated (how to hook people up to a microphone, record with a GPS tracker, write notes, take photographs), there are also privacy-related ethical issues with tracking and recording participants (Jones et al. 2008).

The advantages and disadvantages noted by other authors also played a role in my research. We walked with one or two canal leaders from the start to the end of the secondary canal (or vice versa), while interviewing them about water division, infrastructural development, agricultural practices and anything else that came up. In order to reduce the technological complexity and maintain an easy atmosphere, I did not record the audio of the interviews. I did map the locations in a handheld GPS, took photographs and noted down answers to the questions, referencing the GPS points where the answers were given. This led to a record where statements, images and locations could be linked to one another. I found that where the semi-structured sedentary interviews were helpful for getting a first impression about the history of the scheme, its functioning and the interviewee's experiences during irrigation improvement projects, the walking interviews turned out to give more insight in the relationship between the canal leaders, the infrastructure, the irrigators, the fields and the (lack of) water. Farmers' own infrastructural developments were largely ignored by the interviewees during the sedentary interviews, but became one of the main topics during the walking interviews. Similarly, rather general statements about state intervention became more specific and colourful during the walking interviews. Furthermore, observing irrigation practices and the interactions between farmers and their leaders gave more insight in the functioning of the system. Finally, I physically experienced the size of the system by walking over canal edges in hot and sunny weather, which gave me a better understanding of the challenges in managing water division in the Mawala irrigation scheme. We did these walking interviews in all eleven canals, with one canal leader being replaced by a canal member, after the leader showed no interest to participate.

Focus group discussions

In the Mawala irrigation scheme, I conducted sixteen focus group discussions. The scheme has eleven canals, and I conducted separate focus groups with

men and women in eight of these. We asked the canal chairman or secretary of a specific canal to organise the focus groups, requesting participants who irrigated in their canal's command area and who did not hold a leadership position in the canal. We did the focus groups at the leader's house, or in the field, depending on the preference of the participants. The sizes of the groups differed between three and seven participants, and participants generally knew each other. As my main criterion was that people were irrigating from a certain canal, it would have been difficult to avoid this familiarity (cf. Hopkins 2007). This familiarity worked out well in some cases, where people were more comfortable sharing their experiences. In two focus groups however, one person dominated the discussions, in spite of our efforts to include the others. Reflecting on the composition of the groups, this was often due to age differences (with young participants remaining silent), or because the dominating person held a powerful position in the community.

A key characteristic of a focus group is that people interact with each other, rather than only with the researcher (Longhurst 2010). In some of the focus groups, achieving this was a challenge, especially among women. Participants would be hesitant to speak freely, and waited to be addressed individually, which led to stilted discussions. In spite of our efforts to explain who we were, what the meeting was about, and that we wanted people to speak freely, there were still nerves or suspicions (see also section on reflexivity). As Longhurst (2010) recommends, we started with questions we thought people would be comfortable answering (such as their own participation in events, and the challenges they perceived), and then worked up to more sensitive questions (such as their relationship with the government). Unfortunately, this did not always help to overcome the shyness that I mentioned earlier. The best focus groups were those of 4-5 people, who knew each other, were of similar ages, and held similar positions in the community.

Canal leaders were not present during the discussions, to prevent participants from referring us to their leaders for all answers. Themes during the focus groups were the involvement of farmers in infrastructural improvement projects, challenges farmers faced in farming generally and during these projects specifically, the relationships between farmers and their leaders, the changes brought about by the improvement projects, and the relationship between farmers and the government. All focus groups were held in Swahili, recorded and later transcribed. The discussions were led by research assistant Honorata Mselle, who also participated in the translation and transcriptions of the focus groups. Each focus group took between one and three hours, depending on farmers' responses and the time they had available. In some cases, participants left before the end of the focus group because they had to engage in other activities.

The focus groups provided insight in farmers' perspectives on irrigation improvement projects, their expectations and their general perceptions about the relationship between them and the government and them and their leaders.

Questionnaire

The questionnaire that is used for the quantitative analysis in Article 2 was designed and implemented by the SAFI research team in Tanzania and Mozambique. It was administered to obtain quantitative estimates of: 1. the extent to which certain irrigation technologies were used and the conditions which assisted or constrained technology adoption; 2. the extent of the benefits of irrigation and how they were distributed among households in the village; and 3. the extent to which particular constraints were important in limiting the benefits generated by irrigated farming. In this thesis, I used the data collected in Kisangesangeni village in Kahe ward. The random sampling of participants was based on a list of households which was compiled with the help of village leaders. A total of 150 respondents were interviewed: 88 irrigators, 49 non-irrigators and 13 with an unclear irrigator status. The data was compiled and partially organised by researchers at the University of Manchester. I contributed by commenting on earlier versions of the questionnaire, and organised some of the data for Kisangesangeni village so I could analyse it and use it in Article 2. All data is owned by the SAFI project.

Analysis

As is apparent from the methods described above, the analysis for this thesis depends on different data sources. Below I outline the analysis of the different sources.

The focus groups were translated from Swahili to English and transcribed with my research assistant, while I personally translated the correspondence between farmers and the government. During the field work, themes already emerged, which I further developed after reading through the material again. In the case of the shallow wells, it quickly became clear that there were different classes of farmers. I sorted interviews based on well ownership and crops cultivated, and looked for emerging patterns. In the Mawala case, I used the different interviews with farmers and engineers to reconstruct what had happened during the irrigation improvement projects. By triangulating the interviews with the correspondence and records from the government offices, I compiled a plausible timeline of interactions (requests, replies, plans, meetings, implementation, and feedback) between farmers and the government and between farmers themselves. The recurring themes in the focus group discussions of what farmers considered good irrigation, what problems they saw in their scheme, and how they thought this could best be solved, informed the analysis in Article 3.

The questionnaire data used in Article 2 required some basic quantitative analysis, which was done in excel. Guided by theory on irrigation technology

adoption, I looked for a relationship between irrigation use, wealth, social characteristics (education level, gender, age) and food security.

The collected maps and GPS coordinates were processed with the QGIS software package. I scanned and georeferenced the historical maps. Based on these maps, I drew new maps to indicate the locations of the different historical irrigation schemes. I used my knowledge of the area to correct inaccuracies, and triangulated between maps when possible. As many of the schemes were never implemented, and some of the maps lacked detail, the resulting maps in article 1 cannot be expected to be completely accurate. However, they give a very good indication of the locations and sizes of the historical plans. Combining the maps and reconstructing the past was a powerful analytical tool in itself, because it visualised the scale of irrigation planning which was impossible to fully comprehend when looking at the different maps independently.

I imported the recorded GPS points and used them to create maps of the wells and the Mawala irrigation canals. In the Mawala case, this allowed me to measure and calculate the percentage of the scheme that was in fact affected by irrigation improvement projects. Visualising the irrigation technology also helped me to better understand the functioning of the system, as well as the impacts of certain projects.

Reflexivity

Reflexivity is important in all stages of the research process. It 'involves reflection on self, process, and representation, and critically examining power relations and politics in the research process, and researcher accountability in data collection and interpretation' (Sultana 2007, 376). As such, it is a prerequisite for doing ethical research (Brydon 2006).

Positionality

While doing fieldwork in Tanzania, my positionality was always shaped by my skin colour: I am a white person. Furthermore, and linked to that, as I will discuss below, I was considered to be an expert: an external person who had gone to university and was a carrier of knowledge. At times, my age and my gender also played a role. Below I discuss what these different aspects meant, and how they played a role in my research.

Lopez (2005) rightfully argues that 'whiteness remains behind in the new postcolonial state, in the form of both actual white subjects (…) and the cultural and ideological apparatuses that continue to reflect the values of the colonial regime' (13). He adds to this that 'whiteness in the postcolonial moment continues to retain much of its status and desirability, if not its overt colonial-

era power' (Lopez 2005, 2). Meanwhile, Faria and Mollett (2016), in their reflections on fieldwork in Honduras and South Sudan, show that specific histories and geographies influence what whiteness means in any given location and any given time. These insights warrant a reflection on what whiteness means in the area where I did my fieldwork, and how this has influenced my research.

The Kilimanjaro region, in which Kahe ward is located, has a long history of white foreigners coming in for a range of purposes. Colonial settlers started estates, development workers built water supply systems, tourists came to climb Mount Kilimanjaro, young volunteers built or rehabilitated schools, and a foreign investor is running the TPC sugar estate. White people are associated with development projects and the inflow of money, or are considered as competition for the area's natural resources. Post-colonial experiences, mixed with colonial racialised structures in which white people were considered superior make that white people are still considered carriers of development, knowledge and modernity. At the same time however, recent conflicts with white estate owners in the area, as well as stories about land grabbing by foreign companies elsewhere in Tanzania, have added a fear of 'investors'. In addition, my research methods (especially interviews, focus group discussions and mapping) matched previous activities by NGOs looking to implement a development project, but were also associated with an investor looking for land. Therefore, my presence led to both hope and trepidation among community members: There was a fear that I was there to 'grab' village land, and the hope that I would bring a development project.

Obviously, I was not there to do either. However, the way I was perceived by community members and village leaders was inevitably tied to my whiteness, and to a lesser extent to my researcher status. At times my dominant and powerful position was partially reduced by my gender and age (25-26 at the time of the fieldwork), but many times it was not (see Heron (2007) for a discussion how the domination of whiteness and expert intersects with, and affects, the subordination of gender in shaping the positions of women development workers in sub-Saharan Africa). Especially in the Mawala case, with conflicts within the scheme and between the scheme and the upstream TPC estate, situations could be volatile. To be safe, we followed the advice and instructions from the cooperative and canal leaders that my research assistant and I, as young women, should not map the canals on our own. This reduced our independence and at times slowed down our research activities as we were looking for somebody to agree to guide us, but it also created many opportunities to do walking interviews and learn more about the scheme. The importance of these precautions became clear in two instances where we were alone in a less populated part of the irrigation scheme and experienced harassment and threats from villagers (not research participants). Although things ended well, it illustrated our vulnerability as two young women in the field.

The willingness of individual farmers, village executives and canal leaders to participate in interviews and guide us around, also has to be seen in the expectations that my skin colour and research activities generated. It was therefore important to clearly discuss my research objectives and possible community gains with research participants from the beginning. This allowed for informed consent (Brydon 2006) and gave people the opportunity to refuse to take part (Willis 2006). In order to manage expectations, my research assistant and I had a strict protocol for introducing ourselves at the village level, and after that with separate interviewees. First, we introduced ourselves at the District Commissioner's office of Moshi Rural District. We asked him for introduction letters to the different villages where we wanted to do interviews. Second, we were introduced at the Village Executive Officer's (VEO) office by a senior researcher of the SAFI project, using those letters. Here we emphasised that we were studying irrigated agriculture and that we were not part of an implementation project (*mradi*). In fact, it was one of the elements of our interview protocol to never use the words 'irrigation' and 'project' in the same sentence, in order to prevent expectations of direct material benefits. We explained that we would do our best to communicate our research results to higher governmental levels, but that we could not guarantee results. After we received permission from the VEO, we started the interviews. When meeting individual farmers, we would repeat that we were researchers, that we received permission from the government and that we could not promise benefits, although we would do our best to communicate our research findings to appropriate authorities. We would then ask whether they agreed to being interviewed. All but two persons agreed. Those who did not agree indicated that they did not see what benefits they could derive from talking to us and preferred to continue with their own activities. We left our phone numbers when asked, so that people could call us or the senior SAFI researcher with questions. This happened only a few times, and primarily to make sure we were who we said we were.

In spite of the careful introductions and attempts to manage participants' expectations, people at times actively portrayed themselves as someone development agencies would want to invest in or were suspicious and unwilling to answer the questions. I triangulated interviews, focus group discussions, observations, correspondence and formal records to interpret and weigh the statements of different interviewees. Examples of excluded interviews were a farmer who insisted to have her name recorded and repeatedly presented herself as a poor farmer while living in one of the better houses of the village, and a construction committee member whose retelling of events did not match any of the other interviews or formal records.

Reciprocity in ethical research

To prevent research from being a purely extractive activity in which only the researcher benefits, reciprocity is crucial (Stevens 2001; Moseley 2007). The sharing of research results in a format and language that makes sense to research participants and the community at large is an important part of ethical research. In addition, we promised research participants that we would come back to share the results when we asked them to participate, and were therefore obligated to do so. Interviewees were most concerned about sharing their challenges with authorities, NGOs and others who might be able to help them. For this reason, I compiled booklets in Swahili and English, which focused on these issues, and included recommendations for these different actors (de Bont 2018a; 2018b) (Figure 6).

Figure 6 - Covers of two feedback booklets with research results for the two different cases, distributed in Kahe ward and at local government offices in Moshi

In the Mawala irrigation scheme, there was also a demand for maps that showed the different canals and irrigated areas, so I added these. In addition, I printed larger and sturdier maps for the irrigation cooperative to support their activities.

I distributed the booklets in the study villages and had two feedback meetings with farmers of the Mawala irrigation scheme. The well irrigators were difficult to reach because they were not represented by an organisation (formally or informally), and the village office was unable to facilitate meetings

at the village level. To be able to provide feedback, I contacted all research participants by text message to tell them when I was coming to share the results, and to let them know that there were booklets with the research results at the ward office. I also discussed the research results and handed out hard and soft copies of the booklets to the village, ward and district officers, as well as to the Zonal Irrigation Engineer, the Pangani Basin Water Officer and a local NGO.

When compiling the booklets, I was conscious about not including maps or other documents that could lead to negative impacts for the interviewees (for instance being charged for water use based on maps I created), while still giving farmers the visibility they were looking for. This was especially important for the shallow wells, where I included a map which showed the prevalence of the wells but not the specific locations.

Article summaries

Article 1: The continuous quest for concrete and control in African irrigation planning: the case of the Lower Moshi area, Tanzania (1935-2018)

Although much has been written about the indigenous irrigation systems of Tanzania, there has been no comprehensive historical study of state irrigation planning. This study fills this gap by analysing irrigation development policy in Tanzania between 1935 and 2018. Based on archival research and using the Lower Moshi area in Kilimanjaro Region as a case study, I carefully analyse eighty years of irrigation policy and state intervention. I distinguish between four periods, based on changes in the perceived role of irrigation and the different actors that were considered important. I also note that the belief in state intervention and formal engineering as necessities for proper irrigation development ran straight through all time periods and were the key factors defining the state's attitude towards irrigation development planning, regardless of the political situation. I conclude that the development narrative of 'modern' irrigation as a driver for agricultural transformation has been successful in depoliticising irrigation interventions and closing the debate on whether irrigation is really the best solution to reduce poverty and stimulate economic growth, and if so, whether state-controlled interventions are the best way to do this. To provide space, literally and discursively, for farmer-led irrigation development in Africa, this debate needs to be opened back up.

Article 2: Neither modern nor traditional: farmer-led irrigation development in Kilimanjaro Region, Tanzania

The debate around what kind of irrigation, large- or small-scale, modern or traditional, best contributes to food security and rural development continues to shape irrigation policies and development in the Global South. In Tanzania, the irrigation categories of 'modern' and 'traditional' are dominating irrigation policies and are shaping interventions. In this paper, we explore what these concepts entail in the Tanzanian context and how they relate to a case of farmer-led groundwater irrigation development in Kahe, northern Tanzania. For our analysis we rely on three months of qualitative fieldwork in 2016, a

household questionnaire, secondary data such as policy documents and the results of a mapping exercise in 2014-2015. In the early 2000s, smallholders in Kahe started developing groundwater. This has led to a new, differentiated landscape in which different forms of agricultural production co-exist. The same set of groundwater irrigation technologies has facilitated the emergence of different classes of farmers, ranging from those engaging with subsistence farming to those doing capitalist farming. The level of inputs and integration with markets vary, as does crop choice. As such, some farms emulate the 'modern' ideal of commercial farming promoted by the government, while others do not, or to a lesser extent. We also find that national policy discourses on irrigation are not necessarily repeated at the local level, where interventions are strongly driven by prioritisation based on conflict and funding. We conclude that the policy concepts of traditional and modern irrigation do not do justice to the complexity of actual irrigation development in the Kahe case, and obfuscate its contribution to rural development and food security. We argue that a single irrigation technology does not lead to a single agricultural mode of production, and that irrigation policies and interventions should take into account the differentiation among irrigators.

Article 3: Farmers' modernisation aspirations and the policy practices of demand-driven irrigation development.

In spite of the recognition that 'participation' is not as simple and straightforward as hoped, the participatory approach to development remains pervasive in many places and fields, including in irrigation development policy in Africa. In Tanzania, a demand-driven, participatory irrigation development approach is combined with a strong emphasis on 'irrigation modernisation' and improvement of so-called 'traditional infrastructure'. This combination has led to an irrigation development policy model that centres around demand-driven irrigation improvement, with an emphasis on projects in which groups of farmers in existing schemes ask for support from the government to upgrade their infrastructure. Defining policy implementation as an interactive process, we use the farmer-initiated Mawala irrigation scheme in northern Tanzania as a case study to explore how this demand-driven irrigation improvement policy model is expressed in actual irrigation development interventions and how it is sustained or challenged by actors at different levels. Based on three months of qualitative research, including mapping exercises and interviews with farmers, irrigation leaders and government engineers, we analyse what roles farmers and engineers perform in demand-driven irrigation improvement projects, what their motivations are and what happens to the management and operation

of the scheme as a result of these irrigation improvement projects. We conclude that farmers' aspirations to become modern farmers, re-enforced by external 'experts', drives them to continue to participate in government projects and to actively portray an image of a grateful and peaceful community by covering up internal diversity and conflict. By doing this, they stabilise the demand-driven irrigation improvement policy, but also erode the relations and drives that originally led to the development and maintenance of the scheme. In the end, the success of the policy relies more on achieving the promised increase in area under 'improved irrigation', than on assisting farmers to actually improve their irrigation practices, by for instance reducing management and maintenance requirements or increasing productivity and profitability.

Conclusions

In this thesis, I have explored two contemporary cases of farmer-led irrigation development in Tanzania, with one case having continuous state intervention and the other being largely ignored by external actors. In addition, I have used a historical case to trace the state's attitude towards irrigation development over the last eighty years to illustrate how resilient modernisation thinking has been in irrigation planning. I draw on these three cases to answer my three research questions in order to contribute to our understanding of the roles farmers and the state play in the multi-actor, hydrosocial processes underlying farmer-led irrigation development and the influence of modernity/modernisation thinking in shaping these processes.

How do ideas of modernity and modernisation influence the state's engagement with farmer-led irrigation development, and how does this shape farmers' irrigation initiatives?

For the last eighty years, Tanzanian irrigation development policy has been driven by a modernisation agenda, characterised by state control, formal engineering and the rejection of farmers' irrigation initiatives. Although this time period covers British colonial (1935-1961), socialist (1961-1985) and neoliberal (1985-now) rule, none of these major political shifts were accompanied by a fundamental change in state views on irrigation development. By calling all irrigation developed by farmers traditional, and defining that as unproductive and wasteful, farmers' initiatives are, and have been, a priori disqualified. As the opposite of modern irrigation, traditional irrigation has been considered unplanned, chaotic, and geared towards subsistence farming.

At the core of state engagement in irrigation in Tanzania lies the modernist belief that an irrigation expert is somebody who is university educated and has been taught the latest principles of hydraulic and civil engineering. As a result, this expert is often somebody who has not irrigated or farmed a single day in his or her life. This is not to say that this particular type of knowledge is irrelevant, or invalid, but rather that modernisation thinking has privileged certain types of knowledge, while disqualifying others. Because of this, 'the right irrigation' is never considered the irrigation initiated by the African farmer –

not even when it is through supposedly modern means such as petrol pumps. This is expressed in both Tanzanian policy and practice, where modernisation is equated with external intervention. In the policy, there are no clear performance indicators that determine whether a scheme is modern or improved, making the transition from traditional to improved scheme almost symbolic: the involvement of the state or development agencies is enough to move an irrigation scheme from one category to the next, as if the state's magical touch turns stone into gold. How this works in practice is illustrated by the improvement projects in the Mawala irrigation scheme, where 300 hectares were to be 'improved' – something which was already stated in the project documents before the actual interventions were designed and implemented. The lack of actual changes in irrigation practices, emphasises that interventions are as much political and symbolic as they are technological. The lining of a canal has political purpose for the government ministry which can add to its figures of area under modern irrigation, as much as it is symbolic for farmers who feel one step closer to progress and development. The aesthetic power of technology, as well as of technical experts and their attributes, work their magic on government and citizens alike. Going beyond actual technical performance, the performance of modernity through 'the right irrigation' drives much intervention in Tanzania, and arguably Africa at large.

When modernisation aspirations and the belief in expert knowledge are shared between the government and farmers, as is the case in the Mawala irrigation scheme, this can lead to changes in farmers' relations which impact the scheme beyond changing technology or organisational set-up. The Mawala case shows how farmers, in order to ensure government support, can agree to formalise management and water use, while also disciplining themselves in other ways. Irrigation and village leaders downplay dissent, suppress farmers' construction initiatives, and defer to engineers as the only and true experts of irrigation development. Irrigators are inclined to accept any proposed project, in order to appear grateful and be selected again for another intervention. In combination with a drive from the local authorities to meet project targets, this can lead to interventions that do not actually improve irrigation practices or agricultural productivity. To rationalise the lack of improvements, farmers point at the fact that the experts involved were not truly experts, because otherwise they would have improved their scheme. This circular reasoning explains the continued compliance and cooperation of farmers in government interventions, and reflects farmers' modernisation mind-sets.

Apart from making external intervention imperative, modernisation thinking and the accompanying narrow conceptualisation of farmers' irrigation initiatives also influence which areas are targeted, and what the interventions look like. A waterscape that does not match the state's stereotypical image of a farmers' irrigation initiative in terms of water source, institutional setup or technology, remains unseen or ignored by government authorities in charge of developing irrigation, as is illustrated by the case of farmer-led groundwater

development in Kahe. The Mawala irrigation scheme on the other hand, fits the state's idea of what a farmers' irrigation initiative looks like, and is therefore clearly on the radar of local authorities. In terms of irrigation interventions, much of the state's engagement with farmers' irrigation initiatives has taken the form of technological upgrading and institutional formalisation. This approach is captured in the demand-driven irrigation improvement policy model currently driving state intervention.

This policy model can be seen as a result of the devolution of power to local government authorities in the field of agricultural and irrigation planning in the early 2000s, and the participatory approaches that came into vogue during the 1990s. It claims to give farmers the opportunity to request support from the government, thereby guaranteeing that state interventions have the best possible results. However, rather than empowering farmers to develop irrigation, it has co-opted them into the state irrigation development program. Due to the fact that the irrigation policies and irrigation development guidelines, as well as government officials, show a clear bias towards schemes that have a formal association and water use permit, interventions are directed toward those areas where farmers have already formalised their water use. If this is not the case, infrastructural interventions have to be accompanied by the institutional formalisation of a farmer-initiated irrigation area. In Mawala, farmers have repeatedly requested and received infrastructural support, primarily in the form of the lining of canals and the construction of division boxes. However, all infrastructural projects were preceded by the formalisation and centralisation of the management of the scheme through a water use permit and irrigation cooperative. While farmers were not forced to formalise their scheme, they were left with few other options if they wanted to obtain government support and fulfil their modernisation aspirations. Arguably, the institutional changes, which are framed by the government as farmer-initiated but are in fact strongly state-driven, have altered the day-to-day functioning of the scheme more than the lining of canals, which has done little to alter irrigation practices. The scheme is still presented as farmer-managed, but the presence of the state through the formalisation of scheme management, the mandatory payments for a water use permit, and the repeated infrastructural projects, has drastically impacted the way farmers relate to each other and to irrigation development.

Both policy and practice show how there is a tension between farmers' desire for material support (either through inputs or infrastructural improvement) and their ability to control the future development, use and management of their irrigation technology: technological support and formalisation currently go hand in hand, increasing the influence of the state in irrigated areas where interventions take place. The farmers using groundwater in Kahe have not yet been recognised by the state, and express the dilemma between wanting to receive support, and trying to remain independent. With unsure benefits and a

real likelihood of being controlled and taxed as part of formalisation processes, farmers want to receive support from the Zonal Irrigation Unit and the District Office, while remaining unseen by the Pangani Basin Water Board (PBWO). This is an example of the different policy domains that farmers engage with, which have different objectives and attitudes towards farmers' irrigation initiatives. In this case, the PBWO has the objective to record, monitor and possibly tax water abstractions. This has been difficult in Kahe, because the system is fairly illegible for outsiders due to the individual nature of the technology. In order to receive support from the ZIU or the District Office, who are tasked with supporting and developing irrigation, farmers would have to be organised and would therefore also become more visible to the agency trying to control and tax their water abstraction.

In conclusion, modernisation thinking has always been at the core of Tanzanian irrigation policy, and has dictated state engagement with farmers' irrigation initiatives. It has made certain types of irrigation invisible for the state, while prescribing only one set of interventions for those areas that have been recognised. All these interventions have been based on institutional formalisation and technological upgrading, driven by a desire for state control and the privileging of specific expert knowledge. At the same time, the pervasive nature of modernisation thinking in the Tanzanian irrigation sector has also narrowed the options for farmers when looking for government support. While farmers share the government's desire to modernise and develop, the current irrigation policy only gives them one trajectory to do so. This trajectory leads to state involvement in all institutional and infrastructural aspects of farmer-led irrigation development, and is likely to harm the exact relations that made farmers' irrigation initiatives possible in the first place.

How do farmer-led irrigation development in the Lower Moshi area and Tanzanian irrigation policies relate to each other?

Most aspects of farmer-led irrigation development in the Lower Moshi area challenge the assumptions underlying Tanzanian irrigation policy – as well as more common assumptions about farmers' irrigation initiatives in Africa. However, farmers themselves also subscribe to the irrigation modernisation discourse, as becomes clear in the Mawala case. Below, I first engage with the ways in which farmer-led irrigation development challenges existing irrigation policy, before exploring how that same policy is supported by farmers' irrigation initiatives.

Solely based on the irrigated area that has been developed over the last eighty years, farmers' irrigation initiatives have had more impact on the Lower Moshi area than public irrigation development. Most government and donor

plans never materialised, and those that did, did not have the desired results. While the Lower Moshi Irrigation Scheme (LMIS) is the only durable irrigation system initiated by the state, farmers have developed extensive areas of irrigated rice production in Mandaka Mnono, Kaloleni and Mawala, as well as groundwater irrigation downstream of the LMIS. As a result, the area developed by farmers is three times the size of the public irrigation area. Due to their upstream location, the irrigation areas initiated by farmers enjoy more water security than the LMIS, which cannot irrigate its whole area in the dry season. This difference in area developed by farmers and the state clearly challenges the policy assumption that the state should be driving irrigation development while farmers lack the knowledge and skills to do so.

With increasing surface water shortages, groundwater is eyed as a way to expand agricultural water use. However, groundwater generally requires bigger investments, and local government authorities consider it a water source for agribusinesses or commercial estates. Farmers in Kahe challenge this assumption however, by investing in pumps and wells in an area where the government considered groundwater development uneconomical in the 1970s. A response to growing markets, new technologies and increasing water shortage, this development in Kahe shows that farmers are quick to react to new opportunities and challenges, that they can invest substantially in groundwater exploitation, and that they are willing to do so without incentives from the government or NGOs.

The shallow well irrigation also shows how agricultural systems based on farmer-led irrigation development can contribute to food security (both locally and regionally) and economic development by producing a surplus of staple and cash crops. In addition, the increased economic activity that has accompanied the agricultural intensification provides opportunities for casual labourers, motorbike operators, mechanics, well diggers, intermediaries, sellers of agrochemicals and pumps, etc. As such, well irrigation in Kahe is contributing exactly to those goals set out in the national irrigation policy, without any government or donor intervention. In addition, the use of motorised pumps on a shallow aquifer is not in line with the stereotypical image of irrigation developed by farmers, which is strongly based on canal systems such as those found on Mount Kilimanjaro.

On the other hand, farmers in both contemporary cases share the desire to modernise and intensify agriculture. They also all express a desire to receive government or NGO support, and feel this is needed to truly develop. As such, farmers share the government's faith in external intervention and expert knowledge. The Mawala case specifically, shows how farmers can share the modernisation ambitions of the government, and can subscribe to the government's policies in an attempt to realise these ambitions. Farmers in Mawala actively pursue infrastructural modernisation, comply with any requirements in terms of institutional formalisation, and model themselves after the nearby 'modern' Lower Moshi Irrigation Scheme. By doing this, they help perform

the success story of the demand-driven irrigation development model, and support current policy implementation in practice.

In conclusion, both contemporary cases once again prove that farmer-led irrigation development is diverse in terms of technology, market orientation, productivity, and engagement with external actors, and thereby challenge the narrow conceptualisation of farmers' irrigation initiatives in the irrigation policy. The success of farmers' irrigation initiatives in the Lower Moshi area in expanding irrigated areas over the last eighty years only adds to that. However, the cases also illustrate how farmers actively look for or desire external intervention by technical experts, and can even participate in the modernisation projects of the state. As such, farmers' aspirations are not all that different from those of the state. However, where the state intervention model has done little to realise those aspirations, farmer-led irrigation development has supported both the intensification and commercialisation of agriculture.

What are the implications of the Tanzanian case for understanding the role of African irrigation policies, on paper and in practice, with regard to stimulating irrigation development in sub-Saharan Africa?

Tanzania is a special case within sub-Saharan Africa due to its long history of farmer-led irrigation development and the state's active recognition of farmers' irrigation initiatives. However, the modernisation drive underlying Tanzanian state engagement with irrigation also defines the irrigation policies of other countries in sub-Saharan Africa, which share a similar colonial past and are part of the same global knowledge network. Based on the conviction that irrigation has to be formally planned, designed and managed, farmers' irrigation initiatives are generally ignored, diminished or considered inferior, instead of being seen as a viable option for irrigation expansion. This leads to state interventions which aim to control, formalise and/or technologically upgrade farmers' irrigation initiatives, and blinds the state to the value of farmer-led irrigation development. The three cases in this thesis illustrate different reasons why this blind-spot hampers African irrigation development.

First, the historical case of the Lower Moshi area shows how over the last 80 years, farmers' initiatives have been more successful in expanding the irrigated area than state irrigation projects. This signals the potential of farmer-led irrigation development in facilitating irrigated agriculture in previously rain-fed or uncultivated areas, as farmers respond quickly to emerging market opportunities or changes in water availability. The case also again emphasises the limits of current irrigation development policies that focus on state-controlled irrigation planning, as many plans have never materialised due to high

investment costs, disagreements between farmers and the state, or unforeseen environmental challenges.

Second, the contemporary case studies illustrate the variety of farmers' irrigation initiatives in terms of water source, technology, level of agricultural commercialisation, institutional set-up and interaction with external actors. They show the agency and adaptability of African farmers in managing land and water, and stress the importance of the socio-economic environment in which these developments take place. Although farmer-led irrigation development has the potential to contribute to the intensification of agriculture, the ways in which farmers are able to benefit from irrigation vary, with irrigation development and commercialisation of agriculture reinforcing differentiation among smallholder farmers. State interventions have the ability to mitigate this growing differentiation and to raise productivity in irrigated agriculture by supporting farmers to gain access to inputs, technology, markets and knowledge. However, different irrigation initiatives need different kinds of support in order to contain risks (water conflict, pests and diseases, social differentiation) and maximise benefits (increased productivity, agricultural commercialisation, food security). Categorising irrigation development in two types (formal/informal; public/farmer-led; modern/traditional) and linking these types to specific policy prescriptions ignores the diversity among farmers' irrigation initiatives, and reduces the chances of positively impacting irrigation development. The case of the Mawala irrigation scheme shows that recognition of farmer-led irrigation development, when combined with a modernisation-inspired policy model, can lead to a mere symbolic upgrading of scheme infrastructure without actually improving irrigation practices. Engagement relying less on policy categories, and more on an analysis of practices, challenges and benefits would have been more likely to support farmers in improving their system of irrigated agriculture.

In conclusion, the Tanzanian case shows that the dominant modernisation-driven policy model reduces the chances of both expanding the area under irrigation, and of increasing agricultural productivity within existing irrigated agriculture. It also warns that mere recognition of farmers' irrigation initiatives is not sufficient, if this recognition is based on fixed policy categories. An appreciative approach towards farmer-led irrigation development that takes into account the diversity among farmers' initiatives stands a much better chance of sustainably and equitably expanding African irrigation and raising agricultural productivities.

Svensk sammanfattning

Efter flera år av relativt små investeringar står utvecklingen av bevattningsjordbruk och ökad jordbruksproduktivitet på den afrikanska kontinenten åter i fokus. Trots att det finns en utbredd kunskap om de investeringar i bevattningsjordbruk som görs av jordbrukare på eget initiativ är det främst storskaliga statliga satsningar som rekommenderas i centrala styrdokument. Samtidigt beskrivs det småskaliga jordbruket som ”traditionellt” och utan möjlighet att bidra till den önskade utvecklingen.

Syftet med avhandlingen är att granska denna snäva syn på jordbrukares bevattningsinitiativ och undersöka hur underliggande idéer om modernitet/modernisering påverkar policy för bevattningsjordbruk och samverkan mellan statsförvaltning och jordbrukare. Studien fokuserar på Tanzania och innehåller ett introducerande kapitel och tre artiklar.

Den första artikeln är en historisk analys av statens syn på utveckling av bevattningsjordbruk och på jordbrukares lokalt utvecklade bevattningsmetoder i Tanzania. Studien visar hur en ensidig föreställning om utveckling till ”modernt” bevattningsjordbruk har bidragit till en avpolitiserad och snäv syn på bevattningsutveckling, vilket också påverkat den historiska utvecklingen.

Den andra artikeln behandlar ett fall där jordbrukare har utvecklat bevattning genom att pumpa upp grundvatten med bensinmotorer. Analysen visar hur olika typer av jordbruksproduktion utvecklats beroende på skillnader i kapitaltillgång och att det råder en variation både mellan och inom de initiativ som görs av jordbrukare. Den här studien lyfter också fram hur ett fall som inte stämmer med uppdelningen i traditionellt/modernt blir osynligt för en sådan policy.

Den tredje studien analyserar ett bevattningssystem bestående av handgrävda kanaler som utvecklats lokalt och på eget initiativ av jordbrukare. Resultaten visar hur en efterfrågestyrd policy för bevattningsjordbruk oavsiktligt kan omvandla ett lokalt initierat och förvaltat system till ett statligt förvaltat system, utan att bevattningsmetoder i området förbättras. Detta har skett genom jordbrukarnas egen anpassning och en gemensam målsättning om modernisering från såväl staten som från jordbrukarna själva.

Sammantaget visar avhandlingen hur ett moderniseringstänkande har präglat policy och praktik för bevattningsjordbruk i Tanzania. Detta tänkande har påverkat attityder och handlingar bland jordbrukare såväl som inom statsförvaltningen och har ofta missgynnat en jordbrukarledd utveckling.

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