The Expansion of Traditional Irrigation in Kilimanjaro, Tanzania

By Mattias Tagseth

Introduction

The largest cluster of the stream diversion irrigation systems known as “hill furrows” in eastern Africa is found on the southern slopes of Mt. Kilimanjaro. The history of this extensive furrow system is relevant to the debate on the history and geography of intensive agriculture in the region. Further, the history of the hill furrows in Kilimanjaro is relevant to current development problems because perceptions of the history and dynamics of water use are used to justify interventions in local water management in response to a perceived water scarcity in the region. The main objective of this article is to test hypotheses about processes in land and water use, two of which have been used to guide policy and interventions in traditional irrigation. The first hypothesis states that the hill furrow system is in decline, as furrow irrigation schemes become redundant with development and the transition to piped water supply. The second, conflicting, hypothesis maintains that the post-Independence era has seen an increase in hill furrow technology driven by population growth. Population growth in recent decades, associated with increase in hill furrow irrigation, is said to cause water scarcity in Kilimanjaro. This explanation appears to be based on a neo-Malthusian model of development, given that neither of its theses seems to be based on historical data on changes, nor on studies of how and when the systems were initiated and subsequently expanded.

Studies of land degradation and deforestation have demonstrated the importance of establishing diachronic data sets to permit analysis of landscape change. In this paper I present a diachronic study of long-term change in irrigation at Mt. Kilimanjaro relevant to the debate on water and development. It is possible to analyze the development of the hill furrow systems on the slopes of Mt. Kilimanjaro while drawing on oral traditions, nineteenth-century eyewitness accounts, and several studies of irrigation covering the


twentieth century. Oral traditions suggest that the technology was established in the region several hundred years ago, and eyewitness accounts from 1848 onwards show that the technology was widespread across the southern slopes of Mt. Kilimanjaro. Interest in the water resources during the colonial periods led to the generation of more detailed data. Data from the 1990s can thus be compared with data on the hill furrow system from the early twentieth century onwards. Based on this analysis I will argue that the development of substantial parts of the irrigation infrastructure appear to predate, and to be out of phase with, the population expansion of the late colonial and early postcolonial period to which it has been ascribed. Due to problems identified with the two aforementioned hypotheses, I will put forward a third, alternative hypothesis, that irrigation infrastructure was fully developed in many highland areas by the early twentieth century. Changes in the twentieth century can thus be seen as a restructuring of irrigation, where decline in irrigation in the densely settled highland areas has been offset partly by increase in irrigation in new areas and partly by increase in scale. A review of the dynamics of hill furrow development shows regional differences in irrigation development and suggests that changes in irrigation are not determined by a single factor, and in this respect several contributing factors are discussed.

**Hill Furrows and Development**

Hill furrow systems are found in many highlands and escarpments in eastern Africa, standing out as “islands of intensive agriculture” in a sea of more extensive land use. This technology of water provision has been important in sustaining substantial settlements and providing food security over time. In the development debate, it has been argued that the hill furrow represents indigenous knowledge, with adaptable solutions and little dependence on external input, which has often been overlooked. Traditional irrigation was mobilized to boost food production in campaigns during severe droughts in 1974 and in 1987, and it continues to play an important part in Tanzanian food security today. “Traditional irrigation” still prevails over the “modern irrigation” sector. Its redevelopment has been devised as a key to improved food security in the Tanzanian irrigation master plan, and several development projects aim to improve or replace it. The system retains its

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5 Widgren, “Towards a Historical Geography of Intensive Farming.”

6 Adams, *Wasting the Rain*.

role in water provision for irrigation and other purposes. The term “hill furrow” was coined to describe systems of water control that rely on stream diversion and conveyance by gravity through canals, while avoiding confusion with furrow irrigation as a method of field-level water application.\(^8\) The cluster of hill furrow systems on the slopes of Mt. Kilimanjaro, locally termed *mfongo* (Figure 1), is perhaps better known than other clusters in eastern Africa, but basic questions of how, when, and why the extensive irrigation infrastructure was developed remain to be answered. The technology was often idealized by outsiders from the early days of colonization onwards, but later also scorned as wasteful, superfluous, and inferior. This debate on the virtues of the *mfongo* system still appears to be unresolved, not only because of continued conflict over the water resources in the area, but also because traditional irrigation practitioners, hydrologists, and irrigation engineers have very different ideas of what constitutes “good” water management and “proper” irrigation practice.

Most *mfongo* schemes remain under farmer management and depend on local resources, technology, and models of management despite past and current attempts at intervention in technology, scheme management, and water management. If such interventions were to be guided by a better appreciation of the development and operation of the system it could help reduce problems and conflicts over water management, irrigation extension, and water provision.

The Kilimanjaro region is currently experiencing a water crisis, perceived as an increasing level of conflict and declining availability of water. The Kilimanjaro glacier has become an icon of global warming following the rediscovery\(^9\) of its retreat.\(^10\) Among several possible contributing or competing explanations are a decline in precipitation, land use change, increase in smallholder irrigation, and increased water demand in other sectors. One of the challenges in making good management decisions to deal with the current “water crisis” is an inadequate knowledge not only of the available water resources but also of their past and present use. Two claims or hypotheses about processes in land and water use in the densely populated districts where the hill furrow systems are found are used to guide policy and interventions in traditional irrigation. A dominant thesis in the analysis of irrigation development in the area is that there has been a substantial growth in “traditional irrigation” on the slopes of Mt. Kilimanjaro in recent decades, and that water resources have been degraded through recent clearing of land for agriculture leading to a reduction in dry season runoff. These processes are seen as consequences of rapid

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\(^9\) The process of glacial retreat is not recent, nor is it a recent discovery. It was commented upon by Hans Meyer after the first ascent in 1889, investigated by Fritz Klute after the turn of the nineteenth century, a matter of renewed studies and public attention in the 1930s and again in the 1960s. See Walter Geilinger, “The Retreat of the Kilimanjaro Glaciers,” *Tanganyika Notes and Records* 2 (1936), 7–20.

population growth.\textsuperscript{11} Despite what can be described as an uncertain empirical support,\textsuperscript{12} this essentially neo-Malthusian understanding has been used to guide the management of water resources in the area, which aims to curtail water use in traditional irrigation. Irrigation extension, on the other hand, has been guided by the notion that the “traditional furrows” are becoming redundant through replacement by piped domestic supplies and that they are inferior as irrigation systems, needing to be replaced with systems that are more efficient in terms of water and maintenance and that are up to the standards of modern irrigation engineering.\textsuperscript{13} An important objective of this article is to evaluate the two hypotheses of change in water use on the basis of historical data. I will also put forward a third, alternative hypothesis, and discuss the dynamics of irrigation development.

The Hill Furrow Systems in Eastern Africa

Canal technology with precolonial roots is found in many highland and some lowland areas in eastern Africa. I will use the term ‘hill furrow’ to designate the tradition in this region, and \textit{mfongo} irrigation to designate the tradition in Kilimanjaro. The schemes are commonly described as gravity-fed, stream diversion irrigation systems, relying on dams of stones, twigs, and mud, and on unlined canals. Water is derived from streams or springs. The stream water is checked by a small permeable dam, or by a stone wall that protrudes into the streambed. Within the river valley, the water is carried on a gentle gradient in a furrow running on an embankment towards the farms on a ridge. Upon reaching the main settlement, the furrow is often divided into permanently flowing secondary branches to provide running water close to most homesteads and fields. It is possible to adjust the distribution of water at this point by placing and adjusting a small pack of mud, twigs, and

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Hill furrow irrigation can be distinguished from flood irrigation practiced in wetlands and other forms of traditional irrigation. One series of stream diversion systems on escarpments can be grouped as a Rift Wall cluster. Adams\textsuperscript{14} mentions examples of such sites at Konso (Ethiopia), Marakwet, Njemps, and Pagasi (Kenya), and Sonjo (Tanzania), as well as the abandoned Late Iron Age\textsuperscript{15} site at Engaruka (Tanzania). A series of hill furrow systems found in the highlands and mountains to the east of the Rift Valley in

\begin{figure}
\begin{center}
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\caption{\textit{Mfongo, meadows and agroforestry groves at Marangu, Kilimanjaro.} Photograph by author.}
\end{figure}

\textsuperscript{14} Adams, \textit{Wasting the Rain}, 90.

\textsuperscript{15} Early Iron Age in Tanzania dates from AD 100–1000, while Late Iron Age dates from 1000–1800. Amin A. Mturi, \textit{Archaeology of Tanzania} (Dar es Salaam: The Open University of Tanzania, 1998).
Figure 2. Domestic drawing point on a secondary branch. Photograph by author.

Tanzania and Kenya has been described by Adams as a “Kilimanjaro cluster” of irrigation.\textsuperscript{16} This cluster includes areas with a higher potential for agriculture. Widgren\textsuperscript{17} distinguishes between grain-based systems in the west and banana-based systems in the east, while Håkansson\textsuperscript{18} distinguishes between low rainfall and high rainfall systems. The Kilimanjaro cluster includes hill furrow irrigation found on Mt. Kilimanjaro in the North and South Pare ranges (Tanzania) (Fig. 3) to its south and in the Taita hills (Kenya) across the plains to the east of Kilimanjaro. Further, the Shambaa of the Usambara Mountains (Tanzania) have similar precolonial traditions,\textsuperscript{19} as is the case in Machakos\textsuperscript{20} and Taveta (Kenya). The technology was introduced to Mt. Meru (Tanzania) by practitioners from

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\textsuperscript{17} Widgren, “Towards a Historical Geography of Intensive Farming.”


\textsuperscript{20} Tiffen, Mortimore, and Gichuki, \textit{More People, Less Erosion}. 
Kilimanjaro. Today, the highest density and the largest cluster of indigenous irrigation schemes are found on the southern slopes of Mt. Kilimanjaro.

Figure 3. The topography and hydrology of the Pangani River Basin. Indigenous irrigation is a long-established practice around Mt. Kilimanjaro, in the North and South Pare Mountains and in the Usambara Mts. Cartography by P. Tengesdal and M. Tagseth.

Archaeological studies have focused on Engaruka on the Rift Valley escarpment, and suggest that irrigation was practiced on terraced and manured fields by the residents of a group of villages from the fifteenth century until the eighteenth century. Several studies have sought to contribute evidence for the possible beginnings of hill furrow irrigation in

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some of the aforementioned contexts, based on oral history through association with chiefly reigns, age sets, and genealogies\(^{23}\)

### The Early Phases of Mfongo Irrigation in Kilimanjaro

The early missionaries and explorers who ventured inland in eastern Africa in the nineteenth century documented the *mfongo* irrigation systems. The missionary Johannes Rebmann walked up the established caravan route from Mombasa to Kilimanjaro in the rains of 1848. He observed water furrows and trenches constructed by the warriors in Kilima (Fig. 4). The practice of stall-feeding that he observed and the use of manure recorded there by Von der Decken in 1861–1862 can be interpreted as indications of intensive agriculture.\(^{24}\) Von der Decken also observed irrigation schemes in several of the small states on the southern slopes.\(^{25}\) In the following decade, New\(^{26}\) reported on the practice of irrigation, and also on abandoned furrows and overgrown defensive trenches, which suggests that there had been a decline in some districts. In the 1880s, Johnston\(^{27}\) reported that the hill furrow network was developed to the extent that it covered almost every ridge in Moshi. Thus, by then, the establishment of the technology had become a fact that was verified by independent reports from locations across the southern slopes of Mt. Kilimanjaro. Most of the current traditional irrigation schemes are found in Hai and Moshi Rural Districts on the southern slopes. Irrigation was also practiced in several plains locations with available water. Reports by Volkens suggest that *nduwa* ponds (a type of


small dam defined by having an outlet at the base made with a wooden board that can be manipulated with a plug made of banana fibre) were once more common in Machame, Kibosho, and Old Moshi. Further, he observed abandoned irrigation furrows in Keryo and Ushiri along Ungwashi River in the vicinity of Mkuu Rombo in the 1890s.28 The eastern Rombo District has less surface water on the Tanzanian side, but horticulturalists supply irrigated vegetables to urban markets from Rombo, Kenya, north east of Rombo, Kilimanjaro (see Fig. 5 for locations on Mt. Kilimanjaro).

Figure 4. Furrows can extend from deep gorges and traverse more than 5 kilometres to reach the settlements and farms on the ridges, such as at the deep Ona valley at Kilema, Mt. Kilimanjaro. Photograph by H. Lein in 2000.

*Mfongo* irrigation was thus an established practice across the southern slopes of Mt. Kilimanjaro in the second half of the nineteenth century. However, archaeological evidence suggests that the area has had agricultural settlements since the late first millennium AD.29 What is known about prehistoric periods, i.e., those without written sources? Elders in the area often claim that irrigation has been practised “since time immemorial.” The ethnography of irrigation in the late precolonial period was reconstructed by Gutmann,30 who described the use of irrigation structures in the initiation of boys and in the harvest festival. Water and irrigation were metaphors for life, and could

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convey fertility to land and people.\textsuperscript{31} The brew made from the irrigated crop finger millet had, and still retains, symbolic value. The integration of irrigation in society and culture suggests that irrigation was well established and central to the economy and society. The history of specific schemes on the slopes of Mt. Kilimanjaro has been traced back to 1830–1845 by Masao\textsuperscript{32} through Stahl’s\textsuperscript{33} history of the chiefs, and to the 1830s through oral history from the families of commoners.\textsuperscript{34} Local traditions on the lineage of the chiefs in Marangu and Kilema claim that furrow schemes existed prior to their arrival from Ukamba, and furrows are mentioned in relation to events dating to the seventeenth century in certain areas in Marangu.\textsuperscript{35} Prior to this, we have to rely on other methods from historical landscape studies and archaeology for knowledge of early phases of \textit{mfongo} irrigation.

One possible approach is to investigate the few schemes described with an identifiable location from the periods after 1860. Details are on record of activities in the nineteenth century when spectacular schemes were initiated by members of chieftain lineages,\textsuperscript{36} while local oral history more often suggests that members of commoner lineages from the area, “big men” or families of specialists, were actors in furrow initiation. A number of old schemes in Moshi, Kilimanjaro, were identified and visited by the author in 2001–2002, when examples of both active and abandoned precolonial schemes were found. Two highland furrows in Mbokomu, identified by Masao\textsuperscript{37} as the oldest furrows there, were visited in 2002. These are technically challenging, large schemes, suggesting a mature technology. The family who built the first scheme established its chieftaincy over the area only at a later date. An aqueduct (\textit{ilalo}) had been used to carry water across the rock face in a rather precipitous gorge, but had been replaced later with iron sheets, and subsequently by masonry work. There are several structures for short-term storage in the command areas, with similarities in technology, organization and terminology to the \textit{ndiva} in the highlands of Ugweno in North Pare.\textsuperscript{38} Libations are offered to make the water flow smoothly. Access to the source was formerly restricted to men who had sons, and there are traditions on the construction of furrows recounting how the surveyors were guided by termites.

\begin{itemize}
\item See Gutmann, \textit{Tribal Teachings}; Bender, “Water Brings No Harm.”
\item Masao, “The Irrigation System in Uchagga.”
\item Tagseth, “Oral History and the Development of Indigenous Irrigation.”
\item Ibid, 7-8.
\item Stahl, \textit{History of the Chagga}.
\item Masao, “The Irrigation System in Uchagga.” 8.
\item Interview, Mrs. E.J. Mgonja, Vuchama Ndambwe village, Ugweno Division, North Pare 17 July, 2003. Interview, Mr. Onesmo A. Manga, Mbokomu, Moshi R. District, 2 November, 2002. Collection tanks are also used in South Pare and the Usambaras.
\end{itemize}
Irrigation in Kilema was witnessed by Rebmann in 1848.\textsuperscript{39} The location of fields with the irrigated crop finger millet (*Eleusine coracana*) in lower Kilema in the 1890s was indicated by Lent.\textsuperscript{40} This area still has an active furrow, and it is a center of horticulture. The location of the only major furrow structure in Mwika was also shown. It was long and so wide that sections of it are still visible as a depression in the terrain, despite having been abandoned half-a-century ago when a piped supply was built.

\begin{figure}
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\includegraphics[width=\textwidth]{figure5.png}
\caption{Topography and place names on Mt. Kilimanjaro.}
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Precolonal population and settlement trends are still open to debate, but crisis and contraction of the settlement in the nineteenth century have also been suggested.\textsuperscript{41} Some areas, which are known to have been cultivated or settled in previous periods, fall outside

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\textsuperscript{39} Rebmann, “Journey to Jagga.”
\textsuperscript{40} Carl Lent, “Das Kilimanjaro Gebiet zwischen Moshi und Taweta mit der wissenschaftlichen Marangu-station,” *Mitteilungen von Forschungsreisenden und Gelehrten aus den deutschen Schutzgebieten* 9 (1896), 42.
\end{footnotesize}
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the boundaries of the cultivated areas mapped by Meyer in 1890. The argument that the population was concentrated due to conflict with pastoralists or to increased insecurity following the expansion of the long-distance trade could support the case for the “population pressure” theory of the adoption and expansion of irrigation. Bender mentions security as a motivating factor, along with dry season cultivation. Håkansson has suggested an alternative explanation for the adoption of irrigation, whereby members of the mountain communities in South Pare, Kilimanjaro, were motivated by the regional exchange of grain with groups of people in the plains who were richer in livestock. Irrigation could thus be established under conditions of low population density as a form of regional specialization or division of labor. In another political economy explanation, Fleurét and Sheridan attribute the construction of an irrigation scheme to a strategy pursued by pioneer settlers to attract more dependants and to accumulate wealth in people. In effect, this reverses the postulated relationship between the furrows and population growth. Irrigation schemes in Moshi and Pare are often reported in oral histories to have been initiated during the settlement of (or migration to) a locality, which supports the latter explanation. Based on Kimambo’s suggestions, the adoption of the technology can be described as part of a risk-reducing adaptation to the mountain environment that allowed an efficient exploitation of the different climatic zones defined by altitude through different seasons.

In the late nineteenth century there were more than thirty-five distinct political units on Mt. Kilimanjaro, each under the leadership of a prince (mangi) engaged in shifting alliances and raids, whereby the control over the trade with coastal caravans may have been an important objective. Trade in clay pots, salt (soda), and iron, obtainable in the region though not within most mountain districts, testifies to older established regional trade links. The borders of some districts or “statelets” were reportedly under permanent

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44 Bender, “Water Brings No Harm,” 46–47.


guard, and protected by defensive trenches, in some places in several lines.49 Water was an object of politics, as exemplified by the attempt by the mangi of Moshi to enlist Von der Decken’s party on a raid on the community upstream in Mbokomu because it had taken the water.50 Water could also be used for political purposes: when Von der Decken’s party fled from Uru, a trench was flooded in order to make it slippery and difficult for carriers and donkeys to pass.51 On other occasions, both Johnston and Abbott had their water cut off while negotiating with the mangi of Moshi in order to increase pressure on them.52

The main settlement appears to have extended from ca. 1100 m.a.s.l. up to 1800 m.a.s.l. at the time of colonial impact.53 There were no nucleated villages, only dispersed farmsteads situated in banana groves. Cooking bananas were supplemented by a variety of produce from groves and fields. There were also meadows in the agricultural landscape. Grass and banana pseudo-stems were fed to cattle kept in huts, and the groves were fertilized using cattle manure.54 Some terracing was also used.55 There was a wide variety of farm produce, but agriculture was centered on banana crops and millet fields, with tubers and beans being among the important subsidiary crops.56 The extensive furrow system, some terracing, and evidence for manuring, and the transport of bundles of grass for stall fed cattle, are indications of an intensive agricultural system. However, it can also be argued that irrigation reflected adaptation to the mountain conditions and risk management. Irrigation can enable the area where the more valued mchare variety of banana can be cultivated to be extended down into dryer areas. More significantly, grains do not do well on the middle and higher slopes during the main rains (masika). They are planted in the cool season, when they are susceptible to drought even where annual precipitation is high. Thus, access to supplementary irrigation together with cultivation strategies utilizing the variations in seasonality along the mountain slope would have made survival less uncertain and led to more efficient utilization of labor.

There is clear evidence that there were forested patches, bush, and meadows both within and close to the agricultural landscape on Mt. Kilimanjaro. The agricultural landscape in Moshi was described as characterized by “rising columns of smoke,”

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49 Kersten, Von der Decken’s Reisen, vol. 1; Von der Decken’s Reisen, vol. 2.
51 Ibid., 44.
53 Cultivated and settled areas are documented in several route descriptions. The limits of the cultivated areas are shown by Meyer, “Originalkarte des Kilima-Ndscharo,” and Lent, “Das Kilimandjaro Gebiet.”
probably from field preparation.\textsuperscript{57} Reports from 1899 and 1939 describe the cultivation of finger millet on an irrigated and manured swidden (citemene), which would subsequently have been used for less demanding crops.\textsuperscript{58} The irrigated swidden presents a challenge to our understanding of irrigation as a land-intensive agricultural practice. It is difficult to know to what extent resources were stretched, or whether the societies on Mt. Kilimanjaro had experienced a decline. It is possible that the area may have experienced cycles of growth and decline prior to the mid-nineteenth century. Kjekshus and Wimmelbücker have argued that the expansion of the coastal trade and subsequent colonization was a demographic disaster.\textsuperscript{59} The legends from Mamba (an important center in the period preceding the Swahili trade) mention disaster due to drought and overpopulation during the rule of the rainmaking chieftainess Mashina in ca. 1800.\textsuperscript{60} Accounts of abandoned banana groves,\textsuperscript{61} overgrown trenches\textsuperscript{62} and abandoned house sites located in the high forest\textsuperscript{63} from the 1860s onwards tend to support the thesis that a crisis had been experienced in the mid-to late nineteenth century.

Colonial conquest brought missionaries, and after 1885 German officers arrived, and eventually settlers. The missionaries at Mamba entered into partnership with local agents who built a new and bigger furrow into a watercourse above neighboring Marangu, nicknamed the “furrow of blood” after the resulting conflict.\textsuperscript{64} The first statutory water laws were partly motivated by the need to handle such conflicts between European settlers and the local Chagga.\textsuperscript{65} When colonists arrived to farm in lower Marangu after the turn of the century, they copied the technology, expanded existing furrows, and constructed new schemes when they occupied the land,\textsuperscript{66} mostly on the lower slopes. Land across the lower slopes, used more extensively by the Chagga, and to some extent by the Maasai,


\textsuperscript{58} Widenmann, “Die Kilimandscharo-Bevölkerung,” 71; J.R. Curry, “Eleusine Cultivation by the Wachagga on Kilimanjaro,” \textit{The East African Agricultural Journal} 5 (March 1939), 386–90.


\textsuperscript{60} Wimmelbücker, \textit{Kilimanjaro}.

\textsuperscript{61} Kersten, \textit{Von der Decken’s Reisen}, 1.

\textsuperscript{62} New, \textit{Life, Wanderings and Labours}.

\textsuperscript{63} M. Merker, “Rechtsverhältnisse und Sitten der Wadshagga,” \textit{Petermanns Mitteilungen Ergänzungsheft} 138 (1902), 40.

\textsuperscript{64} Interview by author, Mr. Alois Merishani Mlay, Marangu West Ward 26 February, 1996.


\textsuperscript{66} As shown by the water rights records of the Principal Water Officer at Ubungo, Dar es Salaam.
who were chased from the foothills into a reserve in 1905–1906.67 was alienated in the first decade of the twentieth century. This lower belt of alienated land made expansion difficult from 1911 onwards, and alienation was suspended.68 British confiscation of estates during World War I interrupted the development of this sector, but most of the land was eventually sold to new settlers. Land alienation on the lower slopes, the creation of a forest reserve that restricted upward expansion, and the rapid increase in coffee as a peasant cash crop coupled with population growth, all pointed towards an imminent land crisis, as was realized by the British administration by 1930.69 Colonial planners described the combined action of land alienation on the lower slopes and the forest reserve as acting like “a vice.”70 The rapid expansion of the area under coffee cultivated by smallholders, together with bananas under shade-providing trees, in the period after 193071 can be seen as one of the responses to a politically induced land scarcity.

The 20th-Century Records and the Two Theses on Change in the Mfongo

The first systematic study of irrigation in the area was made by Gutmann, probably based on fieldwork before the advent of World War I.72 He estimated that there were more than 1000 furrow schemes on the southern slopes of Mt. Kilimanjaro. The more detailed study was based upon his observations in Old Moshi and Mbokomu, where he found sixty-six schemes. These could be classified into different types, according to tenure and water control. The chiefs had initiated a few large schemes, and they had gained control over others, but most schemes remained under the control of furrow elders. These elders were


68 Official measurements showed 0.42 hectares of available land per capita in 1913. Juhani Koponen, Development for Exploitation: German Colonial Policies in Mainland Tanzania, 1884–1914 (Helsinki: Finnish Historical Society, 1995), 630. Data from 1930 calculate to 0.26 ha cultivated land per capita and 0.8 ha of unalienated land, and a population density of 114 persons per km². A.W. Griffith, Chagga Land Tenure Report (Moshi District: Government of Tanganyika, 1930), Appendix b.

69 Griffith, “Chagga Land Tenure.”


drawn from the patrilineage of the furrow initiator, and they had key roles in ritual and maintenance relating to the furrows. The organization surrounding the furrow was defined by the command area, not by kinship. In terms of water control, there was a distinction between spring-fed and stream-fed schemes, between schemes with and without collection tanks (*nduwa*), and between permanently flowing and intermittently flowing furrows. Most furrows in Old Moshi and Mbokomu had collection tanks (*nduwa*), which indicates that the demand placed on the water resources was considerable.

The distribution of water\textsuperscript{73} followed joint decisions at a meeting at the water source (tank or intake). The distribution of water could be organized as a sequence or in time-shares allocated to different irrigated areas, in a cycle starting with the end users (Fig. 6). There were different allocations for various purposes, and separate allocations for the furrow elder on market days. The purpose of water use was mixed. The small short-horned zebu cattle kept in the highlands acquired their water by eating banana stems rather than by drinking, but other domestic uses (brewing, fire control, washing) are recounted in the oral history of water use. According to Gutmann,\textsuperscript{74} the irrigation of banana groves was just as important as the irrigation of the millet fields. While recounting changes in furrow utilization since the time of Gutmann’s studies, elders interviewed during my fieldwork in Marangu associated a decline in highland irrigation with the phasing out of finger millet and a decline in arable cultivation. The pressure on land due not only to alienation and population growth, but also to the demand for land for coffee and banana groves, meant that little land was available for irrigated millet upslope after 1930. Competition for labor for growing coffee crops was another factor. Some millet was cultivated on the lower slope, but by the 1950s it had been replaced by the less labor-intensive maize.

![Figure 6. The sequence of water rotation in a *mfongo* irrigation scheme at Mt. Kilimanjaro in the early twentieth century, as described by Gutmann.\textsuperscript{75} The tail-end users in two blocks were served before the water was redirected to the upstream allocation blocks.](image)

\textsuperscript{73} Gutmann, “Feldbausitten;” Gutmann, “Das Wasserrecht.”

\textsuperscript{74} Gutmann, “Feldbausitten.”

\textsuperscript{75} Gutmann, “Das Wasserrecht,” 419.
The employment of more professional government staff from the 1930s, combined with a stronger interest in the water resources and the control over them, led to increased production of sources. The increased interest was due firstly to early concerns about water for hydropower development downstream and for the new European settlers, and, secondly due to the emergence of plans for new irrigation schemes in the plains that could allow the resettlement of mountain dwellers from congested areas as an alternative to land reform. An irrigation engineer was commissioned by the government, and 602 schemes on the slopes of Mt. Kilimanjaro were identified in a subsequent survey in 1939–1940. The survey of the whole mountain was not completed as planned, but the coverage of certain districts was good, and permits a regional breakdown. Assuming that these districts are representative, it can be estimated that there were between 1,000 and 1,500 furrow schemes at Mt. Kilimanjaro at that time.

Pike, a colonial water warden in Moshi, wrote in 1965 that “there are now so many furrows, most houses on Kilimanjaro are within a very short distance of one.” This statement on the multitude of schemes, instead of the total of 726 furrows from the survey he had made in 1959, may suggest that the original survey was not comprehensive. Despite this uncertainty, the survey suggests that there was a decline in the furrow technology in the period between the two surveys undertaken in 1939–1940 and 1959. Pike suggested that abandonment of furrow schemes was likely to have followed from the development of piped water supplies, which had started in this period. Competing systems of water delivery may have threatened the sustainability of some multipurpose schemes by making purely household schemes redundant, or simply by competing for the same water sources. Social, economic, and technological changes on a larger scale affecting smallholder irrigated agriculture may have played a more important role.

The plans for irrigated resettlement in the lowlands were taken up after World War II, but only limited development resulted from government initiatives in the period before

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79 Pike, “Kilimanjaro and the Furrow System.”


Independence (1961), including a pilot scheme at Uru Chini (Lower Moshi) and the Kimashuku furrow in Machame. Such plans are still an issue when planning land and water use in the region, but the conflict between these plans and the use of water for hydropower downstream and the high demand for water on the higher slopes have made their realization a slow process. More resources have gone into piped water supply schemes, including the construction of three small dams in 1959 in order to facilitate increased settlement in relatively sparsely populated upland areas in Kirua Vunjo that had poor access to water. Transition to piped rural domestic supplies after 1950 was intended to reduce water consumption through increased efficiency, according to Bender.

The thesis of a decline in indigenous irrigation was adopted in the 1970s by the Japanese International Cooperation Agency, which used its estimate that peasant irrigation upslope had halved since its peak, and was down to 500 schemes, as a basis for assessing the availability of water for a major lowland irrigation project. The Lower Moshi Irrigation Scheme, operational from 1987, has become rather stunted by poor access to water in relation to demand, apparently due to an underestimation of the extent of irrigation prior to project, and to the changes in cropping pattern it inspired among the upstream irrigators who appropriated green revolution technology more selectively. The hypothesis of a decline thus led to an underestimation of the dynamism and vitality of the furrow system, and can be rejected, but with the provision that a decline did take place in certain areas. While some instances of abandonment correspond to the construction of pipelines, this process is more closely associated with social and economic changes on a larger scale, leading to changes in the farming system.

**Changing Numbers of Schemes through the 20th Century**

The second hypothesis is that there has been a growth in water use for irrigation in traditional irrigation due to population growth since Independence. On the basis of

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82 Molohan, “Northern Province 1959.”
83 Bender, “Water Brings No Harm,” 257.
86 Bender, “Water Brings No Harm,” 263.
analysis of data from a field survey by Pangani Basin Water Office, it is estimated that there were ca. 1,000 furrow schemes at Mt. Kilimanjaro in 1992–1993, probably slightly less than in 1939–1940 when the number of schemes may have peaked. Analyses of changes based on three areas selected to represent the three main regions of the southern slopes of Mt. Kilimanjaro (Table 1), are more reliable, however. Marangu is situated on the south-eastern slopes in Vunjo, while Old Moshi and Mbokomu are on the south-central slopes in Moshi Rural District. Machame is located on the south-western slopes and lies within Hai District (Fig. 5). From 1939–1940 to 1992–1993 there was a marked decline of 41 percent in the number of schemes in Marangu, but a moderate increase by 28 percent in a part of Machame. The number of furrow schemes in Old Moshi and Mbokomu in the 1910s was comparable to that in the 1990s (within 2 percent).

Table 1. Changes in the number of mfongo irrigation schemes in three sectors of the southern slopes of Mt. Kilimanjaro.

<table>
<thead>
<tr>
<th>Period</th>
<th>1910s</th>
<th>1930s</th>
<th>1950s</th>
<th>1970s</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marangu</td>
<td></td>
<td>251</td>
<td></td>
<td></td>
<td>148</td>
</tr>
<tr>
<td>Old Moshi &amp; Mbokomu</td>
<td>66</td>
<td></td>
<td></td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Part of Machame</td>
<td></td>
<td>72</td>
<td></td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Mt Kilimanjaro</td>
<td>1000*</td>
<td>602**</td>
<td>726**</td>
<td>500*</td>
<td>1000*</td>
</tr>
</tbody>
</table>

*estimates **partial


90 The PBWO database from field survey undertaken by the Pangani Basin Water Office in 1992–1993 identifies 1,388 “traditional furrows” in the administrative Kilimanjaro Region, which includes the Mt. Kilimanjaro districts of Hai, Moshi Rural, Moshi Urban, and Rombo, as well as the two districts of Pare (Same and Mwanga). In addition to these, a fraction of the 485 registered water rights in the region refer to furrow schemes.

91 Vunjo is the eastern half of Moshi Rural District.

92 By 1930 irrigation infrastructure served at least 19 percent of the cultivated land in the district of Machame through 183 schemes according to Griffith, “Chagga Land Tenure,” 116–117. The area was reduced to be comparable with 121 schemes in a hydrological region centered on Machame listed by Mosgrove, “Watering African Moons,” 253–57.
The somewhat diverging trends in the data do not support a “recent growth” thesis that new schemes were constructed faster than old ones were abandoned. Neither is there any firm support for the thesis of an overall decline in irrigation, allowing for some increase of scale. Rather, the review of hill furrow history in Kilimanjaro supports a third, alternative hypothesis, namely that irrigation infrastructure was fully developed in many highland areas by the early twentieth century, and that there has been no substantial increase in the number of schemes there since the 1930s. Accordingly, subsequent changes should be understood as processes of restructuring and technological change, with decline in some areas and growth in others. A more detailed analysis of two available surveys shows that the amount of water abstracted in the Marangu district in the dry season was the same in 1992 as it had been in 1940.93 An abandonment of schemes in the highlands had been accompanied by a growth in the average size of the remaining schemes and by intensification of irrigation in the foothills and lowlands. Among other factors, these changes could be related to changes in agriculture and the effects of land scarcity.94 The three areas listed in Table 1 include sections of the mountain slope with long established, densely populated farming and irrigating communities. Data do not permit a separate quantitative analysis of the less densely populated lowlands, where an increase in water use since Independence appears likely. Changes and conditions in the lowlands have been addressed by Lein, Lerise, and Beez.95

The establishment and expansion of the considerable infrastructure with mfongo technology can be compared with available data on population (Table 2). The figures from 1948 onwards are compiled from reliable census data, while population data prior to this are drawn from counts for taxation and other purposes.96 Some of the growth prior to 1948

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reflects an increasing ability of the government to count and tax people. The data refer to a “Mt. Kilimanjaro region” consisting of Hai, Moshi Rural and Rombo Districts from the latest population census. The population of Moshi town is included until 1957, but the problems of comparability are small because urbanization was not very significant up to that date. The increase in rural population has been substantial. There was a period of high to moderate population growth from 1948 to 1978, but growth rates have fallen substantially since then. A comparison between the counts of the schemes and the population increase shows that a substantial expansion of the hill furrow infrastructure took place prior to the period of rapid population growth in the second half of the twentieth century which it has been ascribed to.

Table 2. Mt. Kilimanjaro rural population and annual growth rates, 1890–2002.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (thousands)</td>
<td>60</td>
<td>99</td>
<td>128</td>
<td>155</td>
<td>231</td>
<td>359</td>
<td>476</td>
<td>642</td>
<td>741</td>
<td>909</td>
</tr>
<tr>
<td>Annual growth (%)</td>
<td>2.2</td>
<td>3.3</td>
<td>1.9</td>
<td>2.3</td>
<td>4.9</td>
<td>3.3</td>
<td>3.0</td>
<td>1.9</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

The transition to piped supplies for the provision of domestic water can explain only some of the discrepancies. The expansion of the hill furrow systems cannot be explained in terms of a process of agricultural intensification resulting from increased population density in the second half of the twentieth century. Agricultural intensification leading to the adoption of irrigation may have taken place at lower population densities than assumed, or due to localized population concentrations. Some models that can explain the early establishment of irrigation at low population densities, in terms of adaptation, strategies of accumulation, and regional trade, have been mentioned above.

The existence of an extensive irrigation infrastructure cannot be explained in terms of recent population growth, neither does the thesis of a decline fit the data. The changes in irrigation during the twentieth century can instead be described as a restructuring, with decline in some areas and growth in others. Other contributing factors must be sought to account for the development of mfongo irrigation: in the historically and geographically contingent ways that local farmers responded to increasing levels of land scarcity; in technological change; in the changing role of irrigation farming in the economy; and in


policy and planning. The dynamics of change in irrigation and factors of explanation are explored further in the following sections.

The Dynamics of “Traditional” Irrigation

The question of why the practice of irrigation on Mt. Kilimanjaro emerged and expanded has often been raised, but there have been few attempts to discuss the question in relation to the history and geography of the area. Östberg’s study of Marakwet irrigation focused on causation, but the available historical data somewhat restricted the analysis of change. Anderson was able to show how irrigation in Baringo in Kenya could expand and contract under the influence of economic and political factors. Irrigation in Kilimanjaro has evolved, expanded, contracted, and changed through a long series of phases, under the changing influence of several factors.

There are regional variations in the changes in irrigation. Comparing along the horizontal axis across the slope, there are cases of abandonment in precolonial times in locations such as Keryo and Ushiri (Rombo), stagnation (Machame highlands, Old Moshi), and decline (Marangu highlands) in the twentieth century. Taking the vertical axis along the gradient into account, there has been a process of expansion in the lower slopes and lowlands, but a decline or stagnation in the highlands in the late colonial and postcolonial periods. In general, there has been a decline in irrigation since precolonial times in many highland areas in the Pangani River Basin.

The development and expansion of irrigation is often explained as a result of population growth, exemplified by Mbonile’s suggestion of a direct and dynamic relationship between population and resources such as water. While it is reasonable to assert that population as a variable is involved in the changes, the emphasis of this single-factor explanation appears simplistic. The establishment of a substantial irrigation infrastructure on the higher slopes actually predates the population expansion that has been cited as its cause. This raises the question as to whether population can be seen as a

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98 See e.g., Johnston, The Kilimanjaro Expedition; Dundas, Kilimanjaro and Its People; Teale and Gillman, The Proper Control of Water.

99 Östberg, “The Expansion of Marakwet Irrigation.”


101 See Tagseth, “Practices and Changes in Farmer Managed Irrigation.”


103 Mbonile, “Migration and Intensification of Water Conflicts.”

104 See Sarmett and Faraji, “The Hydrology of Mount Kilimanjaro”, 61-62; United Republic of Tanzania–MWEM, The Meeting on Water Utilisation and Shortage; Daluti, Report on the Agro-Socio-
dependent variable for some periods. It appears reasonable to assume that a causal relationship between population and irrigation would lead to a systematic regional co-variation between population densities and density of irrigation infrastructure. A comparison of population density between districts across the slopes of Mt. Kilimanjaro reveals no obvious relationship between the degree of reliance on irrigation and population density, neither in 1934 nor in 1962. Irrigation has in fact declined in locations with very high and increasing population densities (such as parts of the Marangu highlands) from the 1930s to the 1990s. There has been a persistent tendency through several phases for irrigation to expand towards the extensive margin rather than at the intensive core.

The Highlands

The processes of change differ between the agro-ecological zones. I will discuss highland and foothill processes first, before moving on to changes in the lowland. Early innovation or adoption of irrigation technology could be seen as a form of adaptation to the mountain environment and as part of a strategy of accumulation under lineage organization. The old local and regional trade networks for salt, pottery, iron, and food may have facilitated irrigated grain production as a regional specialization. Local food trade took place at markets centrally located around the 1,300 m contour, while regional trade took place at markets below the settlement. The latter are described as Maasai markets in the late nineteenth century, where agricultural products were bartered for livestock, milk, and iron.

From ca. 1800, Kilimanjaro was linked to the coast through direct caravan routes from Mombasa and later Pangani. Trade in prestige goods, guns, ivory, and slaves, had wide but regionally differing impacts on local economy and society. Among other things, large caravans added a new market for food. The process of political centralization on Mt. Kilimanjaro in the nineteenth century can be better explained by the effects of long distance trade than the need for coordination of irrigation activities. The apparent abandonment of irrigation north of Rombo Mkuu in the nineteenth century can be related to political and economic change. The change of coastal trade routes from the eastern to the southern slopes of Mt. Kilimanjaro led to a decline in Rombo, and the change in

Economic Situation; IUCN, Pangani Basin, 71-72; Mbonile, “Migration and Intensification of Water Conflicts”, 43, 63-64.


106 A regionalization into a lowland zone (below 900 m), a foothill zone (900–1,250 m), and a highland zone (1,250–2,000 m) simplifies the substantial variations in natural conditions and land use along the gradient.

107 Lent, “Das Kilimandjaro Gebiet”; Volkens, Der Kilimandscharo.


109 Moore, Social Facts and Fabrications.
political and economic dominance with the establishment of the German headquarters in Marangu meant that the area could be raided. Increased warfare and changes in the control over trade may have created centers where investment in irrigation was feasible as well as unfortunate districts where irrigation infrastructure, fields, and terraces were abandoned, as recorded in the travelogues. Irrigation infrastructure expanded in the highlands across the southern slopes during the nineteenth and early twentieth century in order to cater to new settlements. Maize was known in the late nineteenth century, but not widely cultivated. Finger millet production motivated the construction of new irrigation schemes. The need for water for new arable outfields can explain why irrigation development during several phases often has taken place on the extensive margin and not as intensification at the core.

Finger millet has good storage properties and a high market value, and could be traded, hoarded, and redistributed as grain or in the form of beer. Today, mbege brew made with millet and bananas is used for ceremonial occasions because of its symbolic value. According to oral histories, mbege had prestige value, it was required in the mobilization of labor parties, it was paid as tribute (mashiro) for land, and as part of bride-price along with livestock. Banana groves probably produced more calories per acre, but irrigated millet was important in the production and appropriation of a surplus that could be traded, circulated, and invested in social relations. According to Bender, it was “used as a form of currency” in the precolonial economy, but the details of how it entered the regional trade, with Maasai for livestock, Wagweno for iron and pots, or the Wakae for salt, is a matter that may need further research. In the late nineteenth century, a powerful warlord, such as mangi Sina of Kibosho, had stores that could hold as much as 350m$^3$ of the grain, some of it bartered from landscapes to the east. The wamangi maintained warriors at their courts, and thus their power, through their control of external trade and the redistribution of grain in the form of beer, as well as livestock and prestige goods acquired as booty and “tax.”

German colonization brought new changes including conquest and pacification, land alienation, the requirement to pay tax, increased availability of imported goods and, after 1911, urbanization at the railhead in Moshi. Together with rinderpest, which decimated the livestock population (especially in the plains), this would have led to profound changes in regional trade. Other areas developed into labor reserves, but at Mt. Kilimanjaro farmers eventually became peasants engaged in production for subsistence and the world market. Technological changes included new cultivars, the most important of

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10 Wimmelbøcker, *Kilimanjaro*.
13 Bender, “Water Brings No Harm,” 50.
14 Volkens, *Der Kilimandscharo*, 136–37. Finger millet is normally stored as unhusked ears.
which was coffee. Kilimanjaro became a war zone when the Germans lost the colony to the British in World War I. During British rule, millet was replaced by the less labor-intensive maize, while the widespread adoption of coffee as a peasant crop facilitated intensification through the expansion of agroforestry groves. Coffee cultivation by peasants probably started on local initiative, but was official policy from the mid-1920s. This form of intensification led to increased reliance on bananas and mixed agroforestry for food rather than an intensification of irrigated grain production in the highlands. This change appears to signal a decline in millet production and in investment in irrigation in the uplands. The change in technology to piped supplies after World War II is another factor in the decline in the furrows. While upland areas were converted from pasture and fields to groves, arable cultivation was extended in the foothills during the colonial periods, with maize as the dominant grain. Informants commented on how maize emerged as a co-staple, and by the 1950s the Northern Province, and mainly Mt. Kilimanjaro with other volcanic areas, was the leading producer in a regulated market. New irrigation schemes were constructed in some areas in the foothills, elsewhere existing schemes were extended. Commuting from the highlands to cultivate arable fields downhill became an increasingly important strategy pursued by peasants and colonial planners, as far as competition with the estates for land would allow. Later, the foothills became a zone of expansion for settlement and agroforestry. Supplementary irrigation of groves is now more common in this zone. The foothills have seen an increase in irrigated horticulture, benefiting from the liberalized agricultural economy developed after 1986 and good road access.

The Lowlands

In the late precolonial period, the lowlands were used by the Kahe, Maasai, and others, and were not controlled by Chagga groups. Maasai use of the Kilimanjaro lowlands was prohibited by the German colonial government and was probably permanently reduced. Some areas were alienated by the Germans. Reservation of the remaining lowland areas for Chagga expansion was confirmed by the British, who sought to establish a political geography of indirect rule, where tribes were defined and supposed to reside within their

115 The Irish potato, Mexican cypress, silky oak (grevillea), cotton, ceara rubber, and arabic coffee were among the important new plants from the German period, according to Robert Munson, “The Landscape of German Colonialism: Mt. Kilimanjaro and Mt. Meru, ca 1890–1916 (Tanzania)” (Ph.D. thesis, Boston University, 2005).

116 Dundas, Kilimanjaro and Its People.


119 Swynnerton, “Some Problems of the Chagga.”

120 Munson, “The Landscape of German Colonialism.”
territory under a “Native Authority.” The Kahe agriculturalists indigenous to the lowlands were classified as a subgroup of the Chagga and were not accorded the status of a “tribe” with a legitimate territorial interest. Other groups, such as the Pare irrigators, were seen as alien to the area. These are some of the preconditions for the designation of the lowlands as an expansion area for the Chagga population on the mountain slopes. The concept of carrying capacity entered the debate on the administration of the region by 1930, and detailed calculations showed a problem of overpopulation on parts of the mountain slopes.121 A planning strategy emerged, whereby “excess” population on the lush, but densely populated, slopes was to spill into the surrounding semi-arid plain, assisted by irrigation.122 In 1937, Provincial Commissioner Hallier wanted to direct the excess population towards an agricultural future within the region, and saw it as his “duty to control and guide the development of these people, and not to allow them to move on in a haphazard manner.” This translated into the “Rau-Himo Expansion Scheme,” the first of a series of plans for Chagga resettlement in the plains.123 This strategy of expansion into the lowlands has been confirmed in postcolonial planning.124 Planners have thus pointed to the semi-arid lowlands as the expansion zone of the Chagga over a long period of time, while slow development can be explained by concerns about water for downstream hydropower production from the 1930s onwards, competition with estates for water, and poor access to funding at least into the 1980s.

Irrigation was established in the precolonial period by Kahe people indigenous to the lowlands, and others in locations in the plains.125 A few schemes were made on government initiatives and more on local initiatives during British rule. For example, land in Lower Moshi was allocated by the chief of Uru in the 1950s.126 Cotton was cultivated in the post-war periods, but phased out in the 1970s due to poor markets, while rice was cultivated as a crop for cash and subsistence in some limited areas. The cultivation of maize with beans and later sunflowers expanded, under supplementary irrigation where possible. Many Chagga actually preferred alternative strategies to resettlement in the lowland, involving intensification and increasing agroforestry upslope, but also education and salaried work, trade, and long distance migration. A few migrated to farm in other districts.127 Thus, some sought a way out of the carrying capacity equation used by the planners by expanding their economic activities beyond the region and the agricultural sector.

121 Griffith, “Chagga Land Tenure.”
122 Lein, “Migration, Irrigation, and Land Use Changes.”
124 Lein, “Migration, Irrigation and Land Use Changes.”
125 Kahe, Arusha Chini, Taveta (Kenya) are known sites.
126 Lerise, Politics in Land and Water Use Management.
127 Examples of Chagga satellites are found in Babati (interview, Mr. Emanuel Moses Mlay, 21 July, 2002 in Haraa village, Babati District) and in Ugweno Division, North Pare (interview, Mr. William O. Mrita, 20 November, 2003).
The rehabilitation of the hydropower plant at Pangani Falls in the 1950s revitalized the conflict between water use for upstream irrigation development and downstream hydropower production. Storage of water in the Nyumba ya Mungo Dam commissioned in 1968 was intended to alleviate this, but international funding for irrigation development was not forthcoming. The policy of “African socialism,” *Ujamaa*, was developed in the 1960s. Villagization in the 1970s involved the concentration of people into compact village communes that could be serviced by state policies and infrastructure such as schools and piped water. The impact on the established, dense settlements upslope was small, but some *Ujamaa* villages were established in the plains, for instance in the Lower Moshi area. Villagization led to redistribution of land (and water) and was a new opportunity for migrants. The nationalization of estates allowed for some redistribution of land, for instance at Himo in the lowlands where immigrants took over the former settler furrows. When severe drought struck nationwide in 1974, a “war on drought” was declared and a call issued to rehabilitate and use traditional irrigation schemes where possible. Some schemes were established or expanded with government support. Old irrigating communities existed in the lowlands, but irrigation probably increased between the 1930s and the 1970s, as Rudengren claims that it was widely practiced in Kahe and Lower Moshi. Settlement and migration histories, however, show that many migrants originated from neighboring groups or as long distance migrants who first came to work on estates or in construction in the area. The expansion of irrigation in the lowlands has some similarities with the changes described for South Pare, which are explained in terms of changes in the regional political economy and the trade in grains. Another call to revive "traditional" irrigation was made during the drought in 1987. A strategy of rehabilitating traditional irrigation schemes emerged in the 1980s as an efficient way of improving food production in Tanzania, with some upgrading funded by the FAO and more recently by the World Bank.

A different course was taken in Lower Moshi, where the Japanese International Cooperation Agency, in line with the Kilimanjaro water master plan, redeveloped an area for water-intensive smallholder irrigation of rice with green revolution technology, including field levelling, cemented canals, mechanization, a new rice variety (IR54), and fertilizers. This intervention restructured irrigation in Lower Moshi and Kahe. It deprived a number of farmer-managed irrigation schemes of their water and reduced the production of rice.

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129 Lerise, *Politics in Land and Water Use Management*; Beez, *Die Ahnen essen keinen Reis*.


132 Håkansson, *Regional Political Ecology*.

133 Burra and van den Heuvel, *Traditional Irrigation in Tanzania*.

134 Lein, “Migration, Irrigation, and Land Use Changes.”
maize under a less water intensive regime of supplementary irrigation over a substantial area. Key elements of the green revolution technology were appropriated selectively by irrigators upstream from the project and some other locations, who used the rice variety and the fertilizers to produce rice as a cash crop. The project area, however, did not have enough water for the planned three crops a year, and a plot would have been cultivated only twice in a three-year period.

The change brought by the development project, which introduced more water-intensive green revolution technology, is one cause of increased water demand since the 1980s. Further changes may result from the objectives to increase the reliance on rice and to modernize the majority of the traditional irrigation schemes under the National Irrigation Master Plan, but this would depend on donor support and the development of an irrigation policy. Another factor is the privatization of estates under the policies of liberalization, which led to the revitalization of dormant coffee estates on the mountain slopes and two large estates irrigating sugarcane in the plains. In Rudengren’s analysis, livelihoods based on irrigated agriculture in the lowlands during Ujamaa in the 1970s, when the food market was strictly regulated, constituted a retreat into subsistence. The adoption of structural adjustment policies after 1986 liberalized the food trade and stimulated the cultivation of grains for the market. A last factor was the rehabilitation of the hydropower plant downstream at Pangani Falls in 1995, which made water not used in irrigation more valuable.

Three factors emerge in the explanation of change in irrigation: population; technological change, including agricultural intensification; and political economy, which includes development planning and economic policies as well as market changes. High and rising population densities in the core areas upslope did not lead to intensification of irrigation there during the twentieth century. This can be attributed to the form of intensification that took place. Irrigation of arable fields declined, while intensification led to increased reliance on agroforestry with coffee and banana, and an increase in mulching and shading as methods of soil water management. This path of change in turn depended on a policy conducive to peasant production of coffee, and the abolition of the system of compulsory work, and a labor card system early during British rule.

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135 Beez, Die Ahnen essen keinen Reis.
136 Ikegami, “The Traditional Agrosilvopastoral Complex System.”
137 Beez, Die Ahnen essen keinen Reis.
140 Rudengren, Peasants by Preference?
technology to piped domestic supplies may have reduced the importance of the furrows in some areas, and led to their abandonment. The needs of an expanding population on the mountain slopes are a part of the explanation for the expansion of irrigation in the lowlands. Migration to the lowland was only one of several strategies pursued by Chagga in search of a livelihood. Preconditions for the lowland expansion include support by the German and British rulers to reserve part of the lowlands for this purpose. The objective of expanding Chagga settlement to the lowlands with the assistance of irrigation appeared in government documents from the 1930s and were reconfirmed in several plans. However, it took a long time to realize this objective due to conflicts over water use and access to funds for major development projects. Increases in water use in the lowland areas have continued under conditions of comparatively low regional population growth since the 1980s, partly due to the introduction of a new rice variety that has made irrigation more water intensive, and to policies of liberalization leading to the privatization of estates and other changes.

Conclusions

This article has outlined the development of mfongo irrigation systems on the southern slopes of Mt. Kilimanjaro. Oral traditions suggest that hill furrow irrigation systems existed by the seventeenth century, while specific schemes and actors can be traced back to the early nineteenth century through oral history. Eyewitness accounts show that hill furrow irrigation technology had already been established across the southern slopes of Mt. Kilimanjaro by the second half of the nineteenth century. The establishment of a substantial furrow infrastructure in precolonial times is probably better explained in terms of adaptation, strategies of accumulation, regional trade, and possibly security, than in terms of intensification driven by population growth. A thesis of rapid growth of these systems in recent decades due to corresponding population growth has been proposed, but there is also a competing thesis of decline due to development and transition to alternative technology. Quantitative analysis of scheme development is possible for the twentieth century. Changes in the number of schemes have been moderate, lending support to the third, alternative hypothesis that many districts in this area were well developed in terms of irrigation by the early twentieth century. The existence of substantial parts of the hill furrow irrigation infrastructure on the slopes of Mt. Kilimanjaro cannot be explained by population expansion in the second half of the twentieth century because the establishment of the infrastructure predates the expansion. Changes in the twentieth century can be seen as a restructuring of irrigation, where declines in irrigation in the densely settled highland areas were offset by increases in irrigation in the foothills and lowlands, and some increase in scale. This observation invites questions about the dynamics of irrigation development. Population increase alone cannot explain the changes, as it is associated with decline or stagnation in long established irrigation areas upslope, and with intensification of irrigation in the foothills and lowlands. Stagnation and decline in irrigation in upland areas under conditions of high population pressure can be related to the decline in arable cultivation and increased reliance on agroforestry as the main method of intensification. The transition to piped water supplies is a contributing factor. An intensification of irrigation has taken place in the foothills and lowlands in periods since the 1930s. The needs and strategies of an expanding Chagga population are involved, but the processes have also been influenced by policy, and technological and market factors. The dynamics of irrigation development
are thus not determined by population pressure alone, but can be interpreted in relation to the historically and geographically contingent ways that the local farmers responded to increasing levels of land scarcity, to technological change, the changing role of irrigated farming in the economy, as well as policy factors.