# Ecological Anthropology: Local Perceptions and Their Responses to Changes in Water Environment and Land Use in the Mount Kenya Region

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Sprinkle irrigation in farmland in the mid foot zone of Mount Kenya

**Abstract** Over the past 50 years, local farmers residing at the foot of Mount Kenya have noticed various changes in the water environment. The volume of water in rivers has decreased, which is particularly evinced during the dry season; and rainfall has become irregular. In addition to these changes in the water environment, changes in land use and population growth have also affected the agricultural industries, and eventually caused water shortages. To provide a sustainable water source and avoid conflicts, furrows have been banned, and projects using pipelines to draw

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and distribute water have been promoted in the upper and intermediate zones of the foothills of the mountain. Furthermore, local farmers have developed various strategies to cope with the problems of water shortages. These include dividing their farmland into different plots and planting different crops, choosing crop varieties that are adapted to dry environments, practicing crop rotation and mixed planting, and building small ponds to store water. Meanwhile, water shortages in the lower foot zone have remained potential sources of conflict.

**Keywords** Water shortage · Land use · Water use · Water project · Mount Kenya

## 1 Introduction

The region around Mount Kenya is locally believed to have three zones. The zone located above 3300 m is known as alpine and moorland zone, and is managed by the Kenya Wildlife Service (KWS) at the Mount Kenya National Park, where any type of local use of the natural resources is strictly prohibited. The forest zone is located between 2400 and 3300 m and is managed by the Kenya Forest Service (KFS) at the Mount Kenya Forest Reserve. Local residents are allowed to graze their livestock (mainly cattle and sheep) at the bottom edge of the forest zone during daytime. The alpine zone and the forest zone function as an important water tower of the region. The lower slopes and foot zones below 2400 m are densely settled and are one of the most important areas for agricultural production in Kenya. Coffee and tea plantations are carried out on the northern, eastern, and southern slopes of the mountain. Large-scale wheat farms are found on the northwest slope, while rice fields cover the southeast foot of the mountain. In addition to large-scale farming, individual farmers who grow maize, beans, and vegetables reside below the forest throughout the region (Fig. 1).

Most of the agricultural areas on the lower slopes and in the foot zones receive an annual precipitation of approximately 1250 mm. The region experiences two rainy seasons: the long rains (April–June) and short rains (November–December). The eastern slopes are relatively humid, while the north and northwest slopes are much drier. Both the alpine and forest zones are vital water sources, and water supply from several perennial rivers and subsurface aquifers are used by the agricultural zones located lower down (FAO 2002).

In recent years, the water environment of Mount Kenya region has changed due to the combined effects of global warming and human activities. Glaciers near the summits have shrunk rapidly and changes in plant succession have been also reported (Mizuno and Fujita 2014). Deforestation and water shortages in the rivers from the mountain have led to conflicts between upstream and downstream users during the 1990s–2000s (Aeschbacher et al. 2005). The impacts of glacial reduction and changes

**Fig. 1** From the summit to the foot of Mount Kenya, the entire region is divided into the alpine zone, forest zone, large-scale farms, and individual farmlands

in the water environment from the alpine zone to the slopes and the foot zones of the mountain are likely to severely impact the agricultural zones in the near future (Otani 2018).

This chapter describes how local residents perceive and respond to changes in the water environment of Mount Kenya from an ecological and anthropological point of view. Fieldwork was carried out in the Naro Moru location on the lower western slope and on the foot of the mountain. The population was approximately 35,000 in 2016, and most of the residents were individual farmers. The area, which is regarded as the driest place of all the agricultural areas that surround the mountain, had an annual precipitation of 800 mm. Residents rely heavily on the river for water for domestic use and for agricultural purposes. The only river flowing in this area is the Naro Moru River, whose water sources are both glacial lakes near the summit and the forest. Therefore, changes in the water environment of the mountain are likely to have significant impacts on local livelihoods and on agricultural production in the area. In this study, we have examined the land use and water use on the lower slopes of the mountain by local residents between 2016 and 2018.

## 2 Local Perception on the Changes of Water Environment in Mount Kenya Region

Although most residents inhabiting the lower slopes and foot zones of Mount Kenya are farmers, the interaction between them and the mountain is not limited to agricultural activities in the Naro Moru region. The Naro Moru route is one of the major routes leading to the summit of Mount Kenya. The Mount Kenya Guides and Porters Safari Club was established in the 1970s in Naro Moru to organize trips to the mountain. In 2017, the club had 149 qualified guides and porters. Among them, 17 people (11%) were registered in the 1970s, 46 (31%) in the 1980s, 40 (27%) in the 1990s, and 46 (31%) in the 2000s. Therefore, approximately 70% of guides and porters had more than 20 years experiences on the mountain. The club also hires another 100–200 porters during high season. As most of these guides and porters also engage in farming in the region, interviewing them provided detailed information on the changes in the water environment, both on the mountain and in the farming areas.

They first pointed out that the glaciers near the summit had not only shrunk more rapidly but also the snow on the top of the mountain had declined dramatically. According to the guides and porters who visited the mountain in the 1970s and 1980s, the area from the Mackinders Camp (at approximately 4200 m) to the summit was covered by more than 30 cm of snow throughout the year. Most of the glaciers were large, and were covered by snow. Some climbers used to ski on the Lewis Glacier, which is Mount Kenya's largest glacier. The temperature near the top of the mountain was low due to the presence of the glaciers. Snow fell during the rainy season and melted slowly during the dry season, which fed the streams and marshes and provided plenty of water that fed the river flowing down to the foot of the mountain. However, with the decline of the glaciers, the snow disappeared rapidly, and the ground near the summit became exposed or covered by vegetation (Fig. 2). As a result, the rivers that pass down the lower slope and foot zones of the mountain have suffered a dramatic reduction in water volume during the dry season. A local elder resident, who first climbed the mountain in 1975 and had served as a mountain guide for more than four decades, described the current situation as "the mountain is sickening."

"In the 1970s and 80s, the mountain was in very good condition. Most of the time, it was snowing and raining. Therefore, there was always plenty of water and snow. However, it is **getting sick nowadays**, it is mostly dry, very dry. Sometimes it gets very dried and dusty around the top."

On the other hand, the belief and respect for the mountain have also changed from generation to generation. The majority of people living in the Naro Moru area are Kikuyu, who believe that God lived on Mount Kenya when he came down from the sky (Kenyatta 1962). Several important ritual ceremonies such as praying for rain during drought were held at sacred sites on the mountain. Interviews with the first generation of residents who came to the Naro Moru area in the 1960s revealed their great respect and deep knowledge of the mountain. Some elders mentioned that they could forecast the weather by watching the shape of the clouds and monitoring the snow on the mountain from their villages, and by smelling the scents brought

**Fig. 2** From the Mackinders Camp (about 4200 m) to the summit, the ground is either exposed or covered by vegetation

about by winds or from specific trees. During severe drought, they used to conduct a traditional ceremony and pray while walking around the mountain. However, due to the influence of modern education and conversion to Christianity, newer generations do not share this special appreciation for the mountain. Young farmers mentioned that instead of watching the clouds and the snow on the mountain, they receive the weather information from the radio, television, and mobile phones.

The second point that people emphasized is that the rainfall has become irregular in the Naro Moru area. The rainy season has been delayed several times since the 1980s, especially after the severe drought of 1984–1985. The long rainy season between April and June has had considerably less rainfall recently. In contrast, there was more rainfall during the short rainy season in November and December. Local residents have explained these changes in different ways. Young, educated people believe it is caused by global warming and climate change, while some elders relate it to the large-scale deforestation that took place in the late 1980s. Nevertheless, they all agree that the volume of water in the Naro Moru River in the dry season has decreased dramatically, and that changes in the rainfall pattern have affected agricultural production.

The third issue raised by the local people was the rapid increase in the demand for water by local farmers and people living in Naro Moru town. The riverside of the Naro Moru River used to be covered by dense forest. However, with the expansion of farmlands, the trees along the river were cut down for construction and furrows were

made to access water. In addition, rapid urbanization and population growth of Naro Moru town have also increased the demand for water over the past two decades.

## 3 Changes in the Land and Water Use in Agricultural Areas

Both land use and water use have changed significantly in the Naro Moru area over the past 50 years. Compared to the eastern, northern, and southern slopes of the mountain, the settlements and farming in Naro Moru area are relatively new. According to local residents, the area was used mainly by Maasai and Samburu nomadic pastoralists as a seasonal rangeland until the late nineteenth century. During the colonial period of the early twentieth century, some white settlers arrived and established large cattle ranches. Following independence in 1963, the Kenyan government split up the ranches and sold them as farmlands via loans to the former ranch employees and farmers, who had migrated from neighboring populated areas. As the population of the area was small, the farmers were able to purchase large areas of farmland in the fertile mid foot zone of the mountain. They planted maize, beans, and vegetables, and their production mostly relied on rainfall.

In the 1970s and 80s, the number of immigrants from the surrounding areas increased. The early settlers divided the farmland and sold part of it to repay the land loan. Most of the land in the mid foot zone of the mountain was occupied. New immigrants had to find land along the border of the Forest Reserve at the upper foot zone of the mountain. Between 1988 and 1990, as landless or land-poor farmers from the north and eastern sides of the mountain continued to arrive in the search for farmland, a section of forest at the bottom edge of the Forest Reserve was cut down to create farmland under a government development scheme. As most farmers only had small pieces of land, and farming that relied solely on rainfall was not stable, water furrows were created to draw water from the Naro Moru River to the farmlands. Cash crops such as cabbage were planted when irrigation became popular. In the 1990s and early 2000s, with the increasing urbanization in Naro Moru town and the expansion of the farmland in the lower foot zone, water shortages became significant and water conflicts occurred in the area.

To provide a more in-depth view of the land and water use along the Naro Moru River, we divided the agricultural area into three sections (Fig. 3).

The upper foot zone of the mountain is the area below the Forest Reserve at an altitude of approximately 2300 m. The temperature in this zone is cooler than that at the mid and lower foot zones, and this area is usually covered by fog in the morning. The slope is relatively steep, and the soil nutrients are considered to be poor. Most residents arrived in this area in the 1970s and 1980s after the mid foot zone became fully occupied. Since the population density was relatively low, the residents were able to farm an area of land between 5 and 50 acres. They cultivated staples such as maize, beans, and potato, and also grew cash crops such as cabbage and carrots.

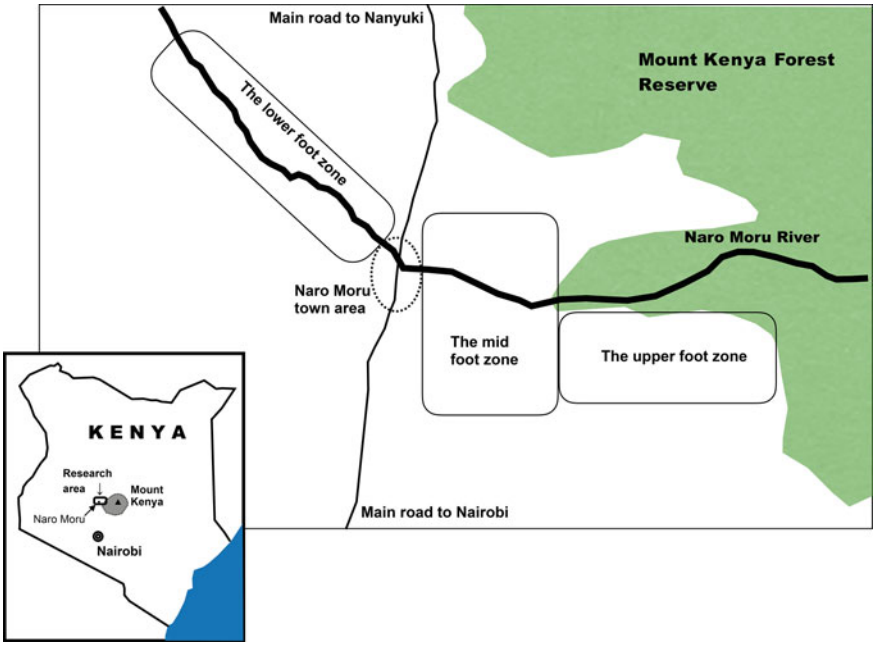


**Fig. 3** From right to left, the upper foot zone, the mid foot zone, and the lower foot zone of the Naro Moru area (the base map was set up by the Water Resource Management Authority (WRMA) office in Naro Moru town)

Some residents also raised cattle and sheep, and these animals were allowed to graze at the bottom edge of the Forest Reserve during the day. People used spring water from the mountain; however, most residents connected the pipelines set up by the water project and used this water for both domestic and farming purposes.

The mid foot zone is the area between the upper foot zone on the east and Naro Moru town on the west. The land is relatively flat and fertile, and the temperature is warmer than in the upper area. It is regarded as the most suitable area for agriculture, and has been densely occupied since Kenya became independent. Most residents of this area are the offspring of the first generation of settlers. As a result of land division and inheritance, farmers own small farms of less than 3 acres. To be able to harvest both staples and cash crops, people practice crop rotation on these small plots. Several homesteads also keep milk cows and sell milk. Irrigation projects using furrows and pipelines were introduced by international development agencies in 1970s to draw and distribute water from the Naro Moru River. Water project committee was established by development agencies to manage the project. The officials of the committee, including a chairman, a secretary, a treasurer, and other officials were selected by the members of the water project.

The lower foot zone lies from the west of Naro Moru town to the point where Naro Moru River meets the Ewaso Ng'iro River. This is a semi-arid area with an

annual rainfall of less than 600 mm. The area is normally used for grazing livestock. However, over the last two decades, new settlers have established large-scale farms and took water from the Naro Moru River. With increasing numbers of these new settlers, conflicts over water sharing have increased among residents of the lower, mid, and upper foot zones of the mountain.

## 4 Local Responses to Changes in the Water Environment and Land Use

### *4.1 Managing the Water Shortage Through Water Projects*

As mentioned above, the water shortages are not only caused by changes in the water environment of Mount Kenya but also by changes in land and water use in the agricultural areas. Local residents recall serious conflicts among themselves in the late 1990s and early 2000s, which was related to water shortage and included the destruction of furrows and irrigation facilities and the attacks on villagers. In the early 2000s, the Kenyan Water Resource Management Authority (WRMA) stepped in to extend their help for solving such problems. As a result, in 2005, all furrows in the upper and mid foot zones were banned. Water projects using pipelines to draw and distribute water, which is managed by water project committees, became the only legal way to access water. Under the guidance of WRMA, water project committees gathered together and formed the Naro Moru Water Users Association (WRUA) to solve water problems and conflicts. However, as no water project was established in the lower foot zone, farmers were allowed to take water directly from the river using their own electric pumps.

Currently, nine water projects have been set up to distribute water in the upper and mid foot zones in Naro Moru area. Among them, four projects are connected to the northern branch of the Naro Moru River (locally known as Tereki River), while five projects are connected to the southern branch of the river (locally called the Naro Moru South River). Figure 4 shows the typical facilities of a water project. For example, each project consists of a reservoir dam across the Naro Moru River. The dam has an intake that connects with the main project pipeline (a 6-inch diameter metal pipe). There is a valve between the intake and the pipeline to control the water flow. The main pipeline is connected to storage tanks. Sub-pipes send water to different locations from the storage tank. Each user of the water project is connected to the sub-pipe by a narrow rubber pipe as well as a faucet in their home and sprinklers on their farm. During the rainy season, sometimes the valve has to be closed to avoid overflow of the tank because people only use the project water for drinking, and the crops are irrigated by the rainfall. During the dry season, the valve is opened only at night to fill the storage tanks, which enables people to use water from the tanks from morning until evening. Below are two examples of the water project in action.


**Fig. 4** Typical facilities of a water project

The Gw Water Project was established in 1975 and was the first project in the Naro Moru region. It currently covers a region that contains approximately 900 homesteads, with 3850 people who live in the mid foot zone of the southern side of the Naro Moru River. Among these, 470 homesteads (52%) have joined the project and 530 pipes were connected to the project pipe. When the project was initiated in 1975, four small storage tanks (135, 103, 25, and 25 $m^3$) were built. A large tank (225 $m^3$) was added in 2005 to meet the demand of the increasing number of water users (Fig. 5). There is no record of the initial phases of the project; however, records for 1990 showed that 183 pipes were connected. In comparison, in 2018, 530 pipes were connected, which implies a three-fold increase in the number of users since 1990.

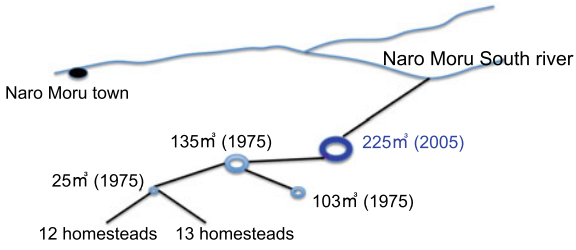


**Fig. 5** Water distribution map of the Gw Water Project

Project officials explained that population growth, land division and inheritance, and new immigrants were the main reasons for the increased water demand. This number accounts for 52% of the total number of homesteads in the project area. The main reasons why people are not being able to join the project include its high registration and construction costs. According to the project committee, the registration fee was 1200 ksh when the project started in 1975. It rose to 15,000 ksh in 2000 and 35,000 ksh in 2018. Furthermore, new immigrants are asked to pay 65,000 ksh as registration and construction fees to join the project, which is equivalent to four months of living costs for a homestead.

The Kb water project was established in 1992 on the northern side of the Naro Moru River. It is the biggest water project in the area and covers a region that contains approximately 1500 homesteads (6500 people) and 8000 livestock. Among these, approximately 700 homesteads (47%) have joined the project. When the project was initiated in 1992, it had approximately 300 members. Furrows were dug to draw water from the Naro Moru River to serve the members. These furrows were used until 1998 when serious conflicts occurred in the area due to concerns over water use. Following the conflicts, 3.2 km of pipelines were laid and a 225 $m^3$ storage tank was built to replace the furrows. Currently, the tank has seven sub-pipes that provide water to 700 users along different directions of the region. In 2018, it costed 61,500 ksh for an individual to become a member of the water project.

According to officials and members of the water project committee, a water rationing program for all projects was introduced by the WRMA, which was operated through WRUA. During the dry season, when water shortages are reported, WRUA holds a meeting and gathers together all the officials of the nine projects and the representatives of the lower foot zone. Subsequently, these officials discuss and prepare a rotation schedule for all the projects to draw water from the river, which is then distributed to all the members. Each project hires staff to open and close the valve at the intake of the reservoir dam according to the schedule. Generally, water is first stored in the storage tank after the valve is opened. Following this, project members are able to store water in their own tanks at home for their daily use and for their crops. For example, during the long dry season of 2016, the members of the Gw Project were allowed to draw water from the river from 4:00 PM to 6:00 AM the next morning every day to fill all five storage tanks, after which they were allowed to use the water in the storage tanks from 6:00 AM to 4:00 PM. Meanwhile, members could only use water from 9:00 AM to 11:00 AM in August 2018 due to lack of water. During an interview, officials of the projects tended to argue the limitation of storage tank as the major problem for all projects and indicated the requirements of financial investment in building more storage tanks. However, the shortage of water in the Naro Moru River in the dry season is obviously the crucial factor of the problem. When the water level in the river fell, the water was only allowed to be used for humans and livestock.

## 4.2 *Managing Water Shortages by Individual Farmers on the Upper and Mid Foot Zones*

Although the water-rationing program helped to reduce tension between the members of the different water projects, the problem of water shortage prevailed. It takes considerable effort on the part of the local farmers to maintain water supply for both domestic and farming use.

In comparison to the rainfall on the northern, eastern, and southern slopes and the foot of the mountain, that on the western side is relatively lesser in amount and also highly unreliable. The Naro Moru area has a limited annual rainfall of approximately 800 mm. Figure 6 illustrates the main crops that are planted and grown in the region. Maize is the staple food for the local people. According to the farmers, several varieties of maize have been introduced to the area by the government, the seeds of which are sold in shops in Naro Moru town. The favorite variety is a cultivar, known as 614, which crops after six and a half months and produces large grains. Another favorite variety is 04, which, despite its smaller grain size, crops shortly after three to four months and requires less water. Farmers said that when water is freely available, they prefer to grow 614; if the water supply is less certain, they grow 04. Generally, farmers start plowing in March and seeding before the rainy season starts. Maize grows well if it receives a stable rainfall during the long rainy season between April and June, which allows farmers to harvest it in August. If the maize grows well, farmers can harvest approximately 1200 kg per acre. After the maize harvest, the farmland is left fallow for one month. At the beginning of October, the farmers start to prepare for the next season.

Potatoes and beans are secondary foods for people living in this area. Potato is relatively resistant to cold temperatures. Therefore, it can be planted in the upper food zone of the mountain. Potato is planted with fertilizers between March and April. Farmers explained that after covering the potato with soil, it becomes warm

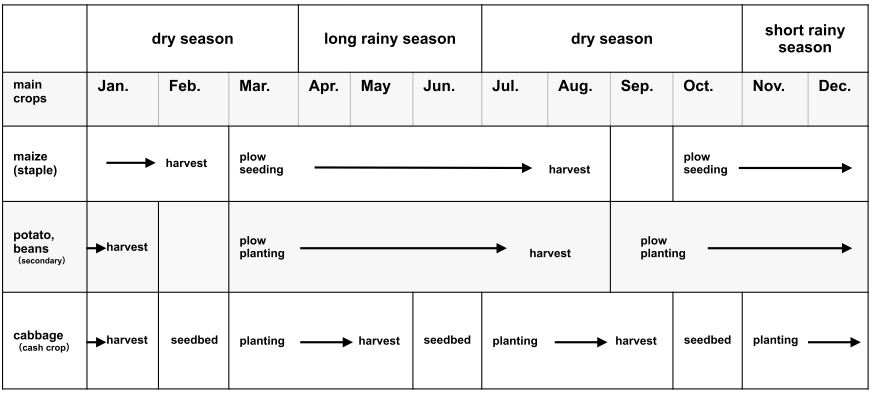


**Fig. 6** Major crops grown in the Naro Moru area

and wet because it releases its own moisture and starts to germinate before the rains come. When rainfall starts and potatoes grow, farmers check them to ensure that their stems are straight, and sometimes soils are added to ensure this effect. Potatoes are harvested during July and August. Beans are normally planted with maize, and do not need fertilizers. Both potatoes and beans are planted twice a year.

The major cash crop in the Naro Moru area is cabbage. It was introduced to the area in the 1980s and spread rapidly in the 1990s when farmers made furrows for irrigation. Since cabbage needs large quantities of water, both rainwater and water from the Naro Moru River are used. The farmers said that if the water supply remains stable, cabbage could be planted and harvested three times a year. Generally, a seedbed of cabbage is prepared between February and March using water from the river. The cabbage seedlings are planted in March and April, when the rainy season starts. If the rainwater supply is stable, cabbage grows well, and it can be harvested by the end of May. Subsequently, the farmers start to prepare the seedbed for the next season if the rain prevails in June. As cabbage crop grows during July and August, it is totally reliant on water from the river. However, in recent years, the water volume in the river has reduced during the dry season, making the cultivation of cabbage difficult. The third cabbage planting starts in early October. Farmers prepare the seedbed using water from the river, and subsequently plant seedlings, when the rainy season arrives at the end of October. As the short rainy season in November and December has become more stable than the long rainy season between April and June, it was found that cabbage grows well during this season and is harvested in January.

Farmers with ownership of different areas of land have developed various strategies to cope with the water shortage situations. Most farmers with large areas of land of more than 3 acres are located in the upper foot zone of the mountain, where the temperature is relatively cool and the soil nutrients are poor. Figure 7 illustrates the crop planting scheme and water use requirement of a farmer with a plot of 3 acres in August 2017. The farmland is divided into four plots. Maize, cabbage, and potato are planted intensively in one plot each. Maize is reliant on rainfall and the other two crops use project water. All these crops are cash crops. The farmer explained that in case lands are available, it is better to plant different crops to avoid the risk of unpredictable rainfall and unsatisfactory use of the project water. For example, maize was planted in March, and the farmer waited for the long rainy season of April. However, the rainy season started in May, and all the maize crops failed. Meanwhile, he planted potato and cabbage in another two plots when the rain started and continued to water these crops with project water after the rainy season. He expected a good harvest of potato and cabbage in September and October. The remaining plot was subdivided to accommodate the house, kitchen, two cow enclosures (one for calves and one for adults), a small garden area for yams, sugar cane, and bananas. Another small area of land was reserved for the cultivation of maize and potato. The farmer mentioned that all the crops in this area were for their own consumption, especially yam, which is a traditional food of the Kikuyu people. The farmer had approximately 10 cows, which are taken to the grassland near the Forest Reserve during the daytime. Milk was used for both home consumption and for selling. After harvesting the maize, the

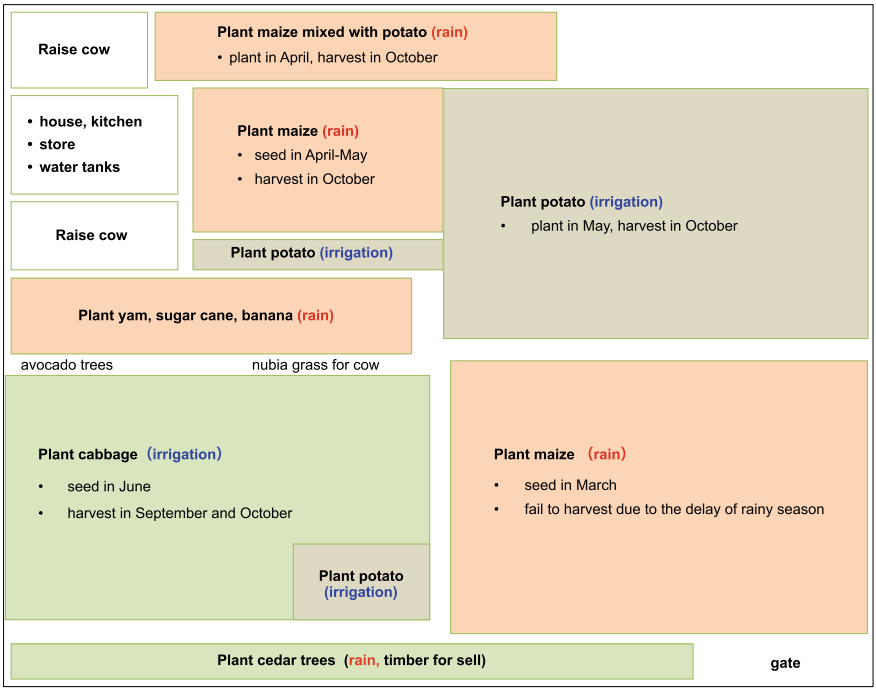


**Fig. 7** A schematic diagram of crop planting scheme and water use requirements of a farmer with a plot of 3 acres in August 2017

cows were taken to the area where the maize was grown so that the cows can feed on the stems. Farmers living in the upper foot zone emphasized the importance of keeping cattle and allowed them to graze on the farmland after the harvest to enrich the soil with their manure.

As most farmers living in the mid foot zone of the mountain have only small farms with areas of less than 3 acres, it is important for them to use the land more efficiently than those in the upper foot zone. Figure 8 shows an example of the crop rotation that a farmer, who owned one acre of land, used to follow in August 2017. Both the farmer and his wife were approximately 50 years old and were born in the Naro Moru region. Their children worked in Nairobi after their education. The farmer divided the land into 10 plots. One was used for housing, kitchen, and water tanks, and another was used for keeping a heifer. The other eight plots were used to plant crops. Among them, five plots were used for planting maize, two for cabbage, and one was fallow land, where he planned to plant cabbage in the next season. Maize was planted for home consumption and its production depended on rainfall. Of the five plots of maize crops, one was planted in March; however, the harvest failed due to the delay of the long rainy season. Two plots of maize crop were planted in May, when the long rainy season started, and these were expected to be harvested in October. Furthermore, two plots of land were planted with maize in

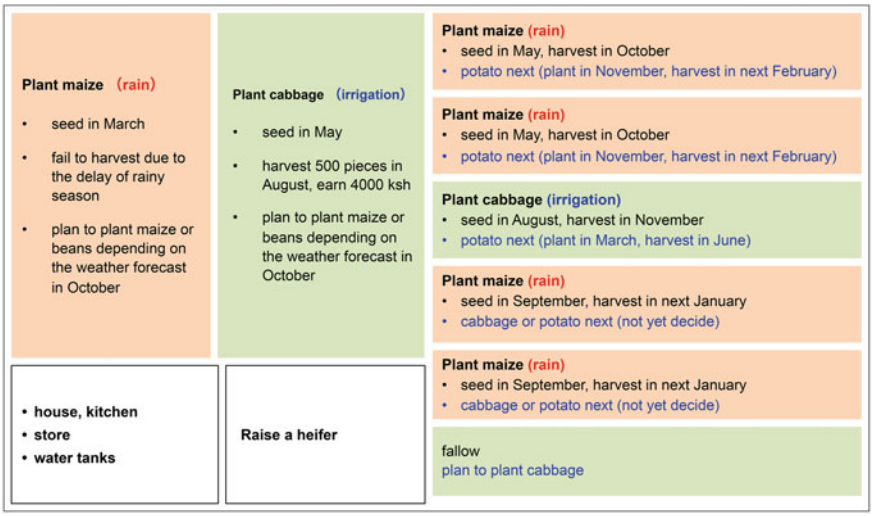


**Fig. 8** A schematic diagram of crop rotation for a farmer with 1 acre of land in August 2017

September. The farmer explained that if the maize received enough rain during the short rainy season in November and December, it would be harvested in January. The two plots planted with cabbage were watered using project water. One was planted in May and was harvested in August. The farmer harvested approximately 500 pieces of cabbage and sold them for 4000 ksh. It was planned that either maize or beans would be cultivated on the land depending on the weather forecast in October. Maize was planted in August, and the farmer expected to harvest it in November. If more water was available, he could reduce the amount of maize cultivation and plant more cabbages. In addition, as both land and water were limited, the farmer emphasized that he had to plant for the current season and make plans for water supply and land fertility in the next season. Sometimes, the farmer has to leave some plots fallow for one season to enable them to recover their fertility.

As approximately 40% of homesteads in the upper and mid foot zones did not join the water project, it is important to understand how they coped with the water shortages. These farmers fell into one of two categories: one, who could not afford to join the project, and two, who had recently migrated to the area.

As an example of the first category, the case of Farmer E is considered, who is a young man in his 30s and lived in the mid foot zone with his wife and one daughter (aged 4 years). His father came from Nanyuki in 1963 and died in 2012. The father had five sons and a daughter. Each of them inherited three quarters of an acre of land. However, the father had only one pipe from a water project, and this was inherited by his daughter. This meant that all of his five sons had to join the project by themselves. Farmer E did not have enough money to join the project. He divided his land into four plots, and planted maize, mixed with beans and potatoes, in each plot in different seasons for his own home consumption. He also dug a small pond to store rainwater.

Without project water, he had to choose only those crop varieties that required less water, and therefore, he was unable to plant cash crops. To generate income, he worked as a porter during the mountain climbing seasons and as a day laborer in Naro Moru town. His wife borrowed water for their daily use from his brothers, who have joined the water project. He insists that as soon as he saves enough money, he will join the water project so that his family will have enough water for themselves and to grow cash crops.

We will now discuss a case of the second category of farmers who recently migrated to the area. Although the mid foot zone in Naro Moru has been densely occupied, some of the first-generation farmers, who own large plots of land had to occasionally sell off their portions. It is also possible to find small pieces of land in the upper or lower foot zones because these places are settled and cultivated later. Therefore, landless farmers from the surrounding areas such as Mulanga, Kianbu, Kalatina, Nyeri, and Meru come to buy land in Naro Moru because land is very expensive in their own regions. Most of these immigrant farmers cannot join the water project immediately because of the high cost or the large distance between their land and the project pipe. Here we have considered Farmer K as an example of a new immigrant farmer. He was born in the 1980s in Karatina (a town on the southern foot of the mountain) and came to Naro Moru in 2009 with his wife and children. His relatives live in the Naro Moru area, and they helped Farmer K find a piece of land in Naro Moru. He bought a quarter of an acre that costed him 50,000 ksh. He said that the price of an equivalent plot would have been 10 times higher in Karatina. He grew some onions, potatoes, pumpkins, and beans for his home consumption, and also prepared a cabbage seedbed. He did not join the water project because his plot of land was too small and the enrolment fee was too high for an immigrant farmer. He also rented another half an acre of land, which is connected to a water project. He grows cabbage for selling to support his family.

During interviews with the farmers, who were not the member of a water project, all of them showed their strong willingness to join the water project even though they did not have the financial ability to do so. Therefore, it is necessary for WRMA and local government, local community, and water projects to establish a social support program so that all the people living in the project area can have access to water for their basic life needs.

## *4.3 Managing Water Shortages by Individual Farmers on the Lower Foot Zone*

The lower foot zone lies in between the west of Naro Moru town to the zone where the Naro Moru River meets the Ewaso Ng'iro River. This is a semi-arid area with an annual rainfall of less than 600 mm. The area has been used as a grazing land by Maasai and Samburu nomadic pastoralists for hundreds of years and by white settlers, who set up cattle ranches during the colonial period. However, over the past

**Fig. 9** Collection of water directly from the Naro Moru River using a private electric pump in the lower foot zone

two decades, with an increasing population and higher demands for farmland, new settlers from neighboring areas such as Nyeri and Meru have invested in large-scale and intensive farming along the Naro Moru River. There is no water project in this zone. Individual farmers take water directly from the river using private electric pumps (Fig. 9).

Interviews with farmers living in this zone have revealed the difficulties and challenges faced by the farmers in this location. During the dry season, farmers have to pump water from the river daily, which requires the use of diesel that is expensive. When the water level of the river falls and water projects operating in the upper and mid foot zones use large amounts of water, downstream areas might face water shortage. Lack of water significantly affects the crops and causes conflicts between the upper-mid zones and the lower zone. Whenever the water does not flow all the way downstream, the farmers complain to WRMA and WRUA and request a public meeting to solve the problem. On the other hand, if it rains heavily in the mountain area during the rainy season, floods may occur in the lower foot zone and all the crops along the riverside might get washed away. Due to these high risks and high cost, instead of seeking stable productivity, most farmers tend to undertake intensive farming of cash crops, which has the potential to be economically productive if the conditions are favorable (Fig. 10). According to one farmer who plants cabbage in a half-acre plot of land, there was a time when he harvested around 10,000 cabbages

**Fig. 10** Irrigation of an intensive cabbage farmland in the lower foot zone

and earned 250,000 Ksh in three months, which is equivalent to 16 months of living costs for a homestead. However, there were other times when he harvested nothing due to a lack of water in the river. Although the use of water from the Naro Moru River is currently controlled by the WRMA and WRUA, water shortages in the lower foot zone remain a potential source for conflict.

## 5 Conclusion

Over the past 50 years, local farmers living at the foot of Mount Kenya have noticed various changes in the water environment. As the glaciers near the summit have retreated more rapidly, the temperature at the top of the mountain has increased and the snow in the alpine zone has melted. As a result, the water volume in the rivers has decreased during the dry season and rainfall has become irregular. The long rainy season between April and June has seen a reduced rainfall; by contrast, higher rainfall has been observed during the short rainy season in November and December. Furthermore, rapid urbanization and population growth in the Naro Moru area have increased the demand for water over the past two decades. All these changes have led to water shortages in the region as most farmers rely both on rainfall and on water from the river originating from the mountain.

To ensure a sustainable supply of water and avoid conflicts, furrows have been banned and water projects that use pipelines to draw and distribute water have been promoted in the upper and mid foot zones of the mountain. Although the water rationing programs introduced by the WRMA and WRUA have helped to reduce tensions in the area, the problem of water shortages remains. Local farmers have developed various strategies to cope with this issue; these include dividing their farmland into different plots and planting different crops, choosing crop varieties that are adapted to dry environments, practicing crop rotation and mixed planting, and building small ponds to store water.

However, as approximately 40% of homesteads have not joined the water project, a social support program is required to enable access to water for meeting the basic needs of all people living in the project area. On the other hand, the population has increased and the demands of farmland have also increased because new settlers have invested in large-scale and intensive farming in the lower foot zone over the past two decades. As most farmers take water directly from the river using private electric pumps, water shortages in the lower foot zone remain a potential source of conflict.

## References

Aeschbacher J, Liniger H, Weingartner R (2005) River water shortage in a highland-lowland system: a case study of the impacts of water abstraction in the Mount Kenya region. Mt Res Dev 25(2):155–162

FAO (2002). Mount Kenya: inappropriate settlement of highlands by lowlanders. In: Ives JD, Highland—Lowland interactive systems, Ottawa, Canada. http://www.fao.org/forestry/webview/media?mediaId=12408&langId=1. Accessed 10 Feb 2019

Kenyatta J (1962) Facing Mount Kenya. Vintage Press, New York

Mizuno K, Fujita T (2014) Vegetation succession on Mt. Kenya in relation to glacial fluctuation and global warming. J Veg Sci 25:559–570

Otani Y (2018) Impact of glacial reduction and change in the water environment on a local community on Mt. Kenya. Geogr Rev Jpn A 91(3):211–228 (in Japanese)