In Chapter 8

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WHAT THIS CHAPTER SHOWS

This chapter examines maps of various ecosystem services and poverty patterns in a single region—the upper watersheds of the Tana River—to demonstrate how such maps can help to highlight the relationships among people, ecosystems, and poverty. After providing a brief overview of landforms, population distribution, and poverty patterns in the upper Tana, the spatial relationships between selected ecosystem indicators and poverty in three topic areas: water-related ecosystem services; food-related ecosystem services; and biodiversity- and wood-related ecosystem services are discussed. The chapter concludes with a detailed summary that highlights poverty for six selected ecosystem indicators and suggests possible future analyses based on the patterns observed.

The Upper Tana: Patterns of Ecosystem Services and Poverty

This chapter focuses on a single region of Kenya and examines a range of ecosystem services used in this region. Unlike Chapters 3–7, which paint broad national pictures of a single ecosystem service such as water or food, here we integrate data on several services to give a more holistic picture of supply and demand in a particular area. The maps show the "key supply areas" of such services as food from crops and livestock; drinking and irrigation water use; and levels of crop diversity and woodlots in agroecosystems.

This kind of analysis is important because ecosystem services are typically looked at on a sectoral basis (e.g., water, forests, agriculture), which misses the interrelationships among them. Overlapping demand for various ecosystem services may produce conflicts over resource use, requiring tradeoffs among different uses and often between different users. Alternatively, there may be opportunities for synergies among different uses of ecosystem services. Mapping and analyzing spatial patterns of the supply and demand for different ecosystem services in the same geographic area can help communities address management decisions in a more integrated manner.

Using spatial analysis to examine a range of ecosystem services in a given area also allows us to compare these with spatial patterns of poverty in the area. It can provide information on how much local communities rely on key ecosystem services, such as food, water, forest products, and wildlife. It can also offer important insights on poverty-environment relationships: It could help to identify areas where natural resource investments could boost environmental income for communities or reduce vulnerability of the poorest households from further resource degradation. Or it could help to locate better-off communities that can afford to pay for land use practices to ensure a continued supply of ecosystem services such as sufficient water for the dry season or migration corridors for wildlife.

The following three sections—water-related ecosystem services, food-related ecosystem services, and biodiversity- and wood-related ecosystem services—provide examples of how to examine these relationships between people, ecosystems, and poverty. They break new ground by showing for the first time in one publication where *key supply areas of ecosystem services coincide* and where both *poorer and better-off communities are located in relation to these supply areas*.

We acknowledge that examining poverty-ecosystem relationships by overlaying two spatial indicators can only provide limited insights: It can show *where* in the upper Tana a proposed hypothesis about the spatial relationship between selected indicators is true and where it is not. In most cases, readers will demand additional information requiring new indicators or more location-specific data. The simple map overlays portrayed here are not sophisticated enough to detect all necessary correlations or come up with conclusive answers about causal links. They represent only a first step in unraveling poverty-ecosystem relationships.

In effect, we hope to use this chapter to engage the reader in a dialogue that spurs new questions and further investigations. We see such a dialogue and analytical process as a necessary step toward managing ecosystems more wisely and identifying opportunities for poverty reduction. It will be the task of Kenya's technical institutions responsible for data collection and analytical products to take the examples in this chapter to the next level. It will also require decision-makers who are motivated to ask questions and to understand the power (and limitations) of the data and the associated tools. We hope that these examples will inspire an improved multisectoral analysis of ecosystem services and of poverty-environment relationships in the upper Tana, and will lead to more detailed cross-cutting studies in other geographic regions of the country.

LANDSCAPES, PEOPLE, AND POVERTY

Several distinctive characteristics make the upper Tana River well suited for in-depth analysis:

- Within Kenya, the upper Tana, which covers a significant proportion of Central and Eastern Province, represents an economically important region for agricultural production and experiences high demand for ecosystem services. The upper Tana region includes the Aberdare Range and Mount Kenya—two of Kenya's five major mountain ranges, and the headwaters for many of Kenya's largest rivers. These rivers are an indispensable source of water for crops, livestock, wildlife, and human use, not only within the mountain vicinity, but also farther downstream across a large expanse of arid and semi-arid lands. In fact, the Tana River is the only major river running year-round through Eastern Province.

- The upper Tana area is home to 3.1 million people (about 11.4 percent of Kenya's total population), whose livelihoods are closely intertwined with multiple ecosystem services. Most of the area is covered by smallholder agriculture. It includes important areas of cash or export crops such as tea, coffee, vegetables, and rice. The government has set aside a significant portion of the land for biodiversity and watershed protection, including Mount Kenya National Reserve, Aberdare National Park, Aberdare Forest Reserve, Meru National Park, and Mwea Reserve.
- This area also contains a broad cross-section of very poor and less poor communities. Within the upper Tana are communities with some of Kenya's lowest poverty rates; however, the area also includes several very poor communities, most of them in the drier plains below the foothills downstream of the Aberdare Range and Mount Kenya.

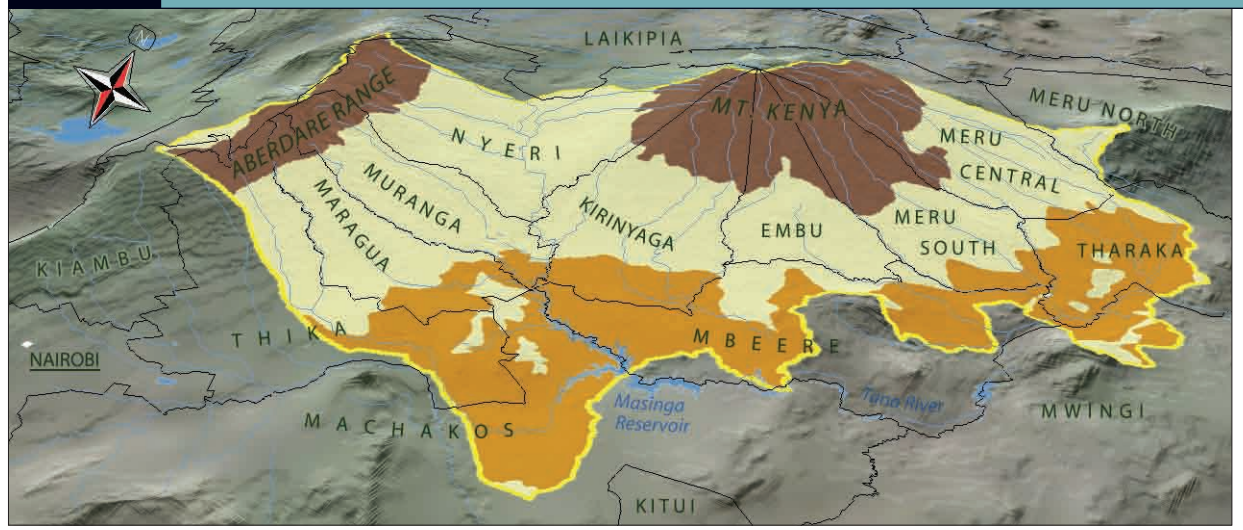
The yellow line in Map 8.1 and subsequent maps outlines the upper Tana area. It represents the common watershed boundaries of all the major permanent streams and rivers originating in the Aberdare Range and Mount Kenya that flow into the Tana River.

Landforms

The upper Tana encompasses some 12,500 square kilometers, with elevations ranging from 1,000 to more than 5,000 meters. Elevation and landforms strongly influence rainfall and thus vegetation and farming patterns. The 60-kilometer gradient from the top of Mount Kenya to the lower plains contains a tremendous diversity of vegetation and farming systems.

The highest peaks include glaciers and alpine habitat types surrounded at lower elevations by tropical mountain forests. Classified as mountainous, these areas make up some 20 percent of the upper Tana (see brown areas in Map 8.1).

Map 8.1 Upper Tana: Landforms and Rivers



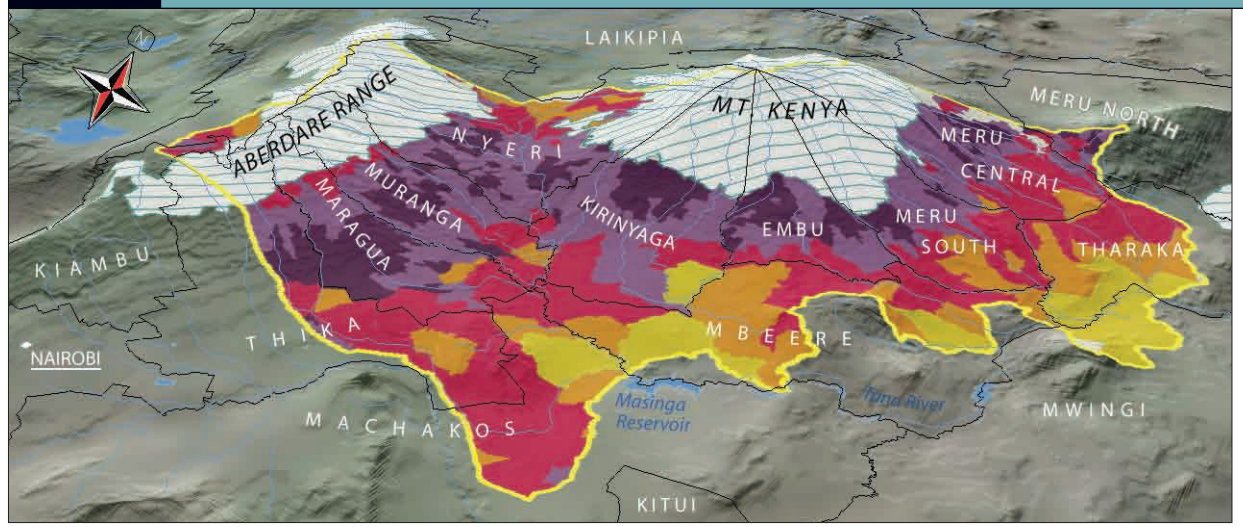
Sources: Administrative boundaries (CBS 2003), permanent rivers (NIMA 1997), 250-meter Digital Elevation Model (SoK, JICA, and ILRI 1996), subdrainage areas defining upper Tana (MoWD and JICA 1992), and landforms (FAO 2000).

LANDFORMS
- Mountains
- Footslopes, hills, and mountain footridges
- Plains

OTHER FEATURES
- Upper Tana boundary
- District boundaries

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Map 8.2 Upper Tana : Population Density, 1999



Sources: Administrative boundaries (CBS 2003), permanent rivers (NIMA 1997), 250-meter Digital Elevation Model (SoK, JICA, and ILRI 1996), subdrainage areas defining upper Tana (MoWD and JICA 1992), and 1999 population density (CBS 1999).

POPULATION DENSITY
(number of people per sq. km)
- > 600
- 300 - 600
- 100 - 300
- 50 - 100
- 20 - 50
- <= 20

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

The mid-elevations are endowed with excellent soils and rainfall and are ringed by belts of tea, coffee, and other crops. This zone is less steep and often categorized as footslopes, hills, and mountain footridges (beige area in Map 8.1). It covers the largest share of the land within the Tana region. Population densities are very high, the land is intensively farmed, and average land holdings are very small.

The low-elevation sections of the Tana region are the least steep and have the lowest rainfall, segueing into the plains of Kenya's rangelands. These lands cover another 30 percent of the region (orange areas in Map 8.1). Dominant land uses are dryland agriculture (such as growing sorghum) or livestock grazing in the semi-arid rangelands.

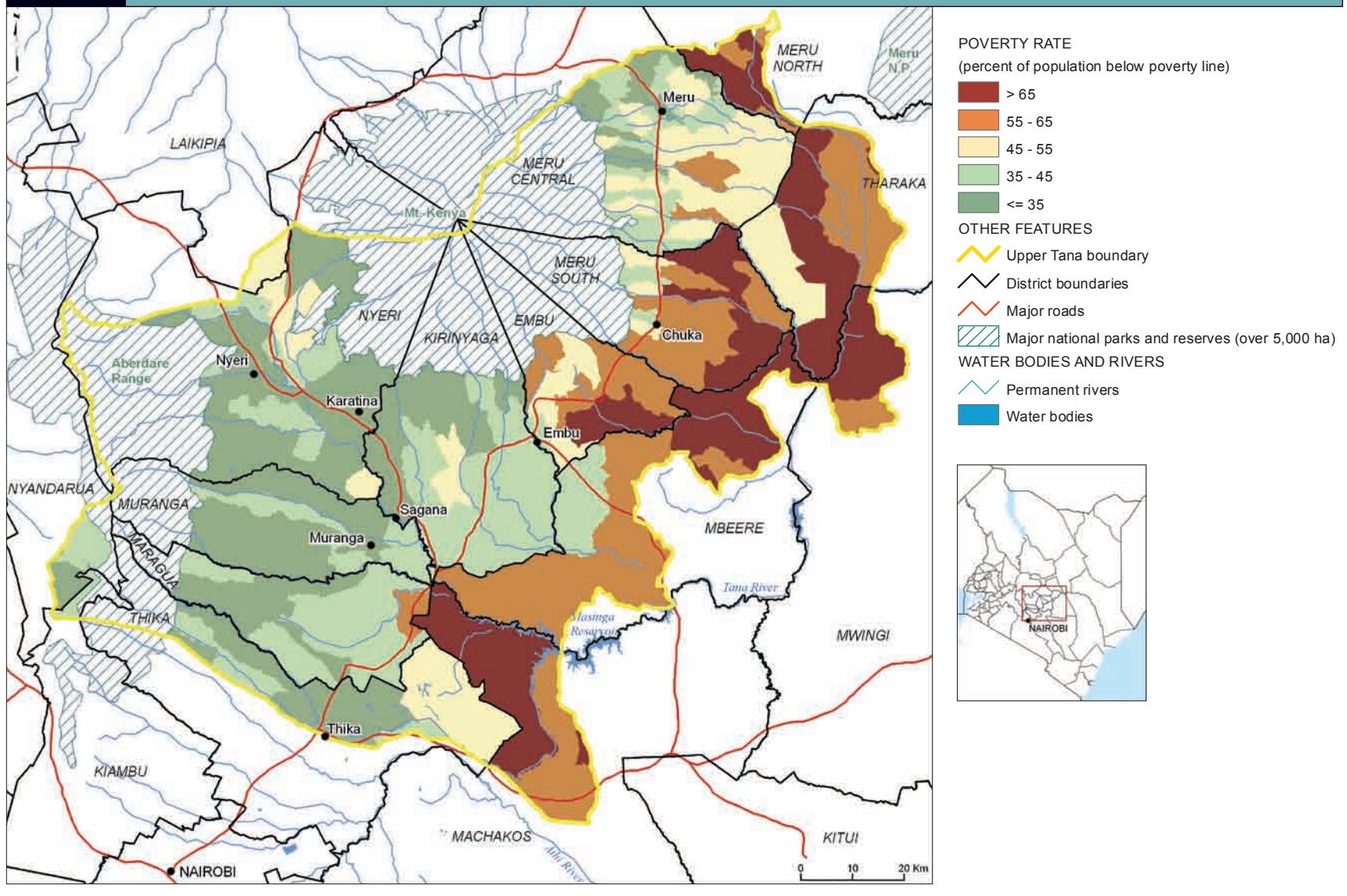
Population, Road Network, and Administrative Units

About 860,000 households live in the upper Tana. The average population density is 250 people per square kilometer. The region includes large protected areas where settlements are not permitted and some of the most densely populated rural areas in Kenya (in Map 8.2, area in dark purple represents densities of more than 600 persons per square kilometer). Population densities in the region's lower elevation areas are generally less than 100 persons per square kilometer (Map 8.2, yellow and orange areas).

The largest towns are Thika and Nyeri. They are connected to Nairobi (45 km and 165 km from Nairobi, respectively) by a major highway. Other large towns are Embu (135 km from Nairobi) and Meru (275 km from Nairobi), connected to the Nairobi-Nyeri highway by asphalt roads. These towns host some agriculture-based industries (e.g., coffee and tea factories, flower farms, milk and cotton processing) and some small-scale timber-based industries (e.g., saw mills and furniture manufacturing). The secondary road network is denser and better developed in Thika, Maragua, Muranga, Nyeri, and Kirinyaga Districts. It is less dense in the remaining foothill Districts of Mount Kenya farther east, and is least developed in the plains.

At an administrative level, the upper Tana includes all or part of 14 Districts (as defined by 1999 census boundaries): Maragua, Muranga, and parts of Thika Districts drain the slopes of the Aberdare Range. Nyeri District includes streams from both Mount Kenya and the Aberdare Range. Kirinyaga, Embu, Meru South, and Meru Central Districts incorporate the southeast and eastern slopes of Mount Kenya. Parts of Mbeere, Tharaka, and Machakos Districts lie further downstream of Mount Kenya in the plains of the Tana River. Small slivers of Meru North District (in the far northeast corner), Nyandarua District (in the far southwest corner), and Laikipia District (just above Nyeri) also fall in the upper Tana region. Together these Districts contain 222 local administrative units (Locations) and 823 subunits (Sublocations).

Map 8.3 **Upper Tana: Poverty Rate, 1999**



Sources: See Map 2.6.

Spatial Patterns of Poverty

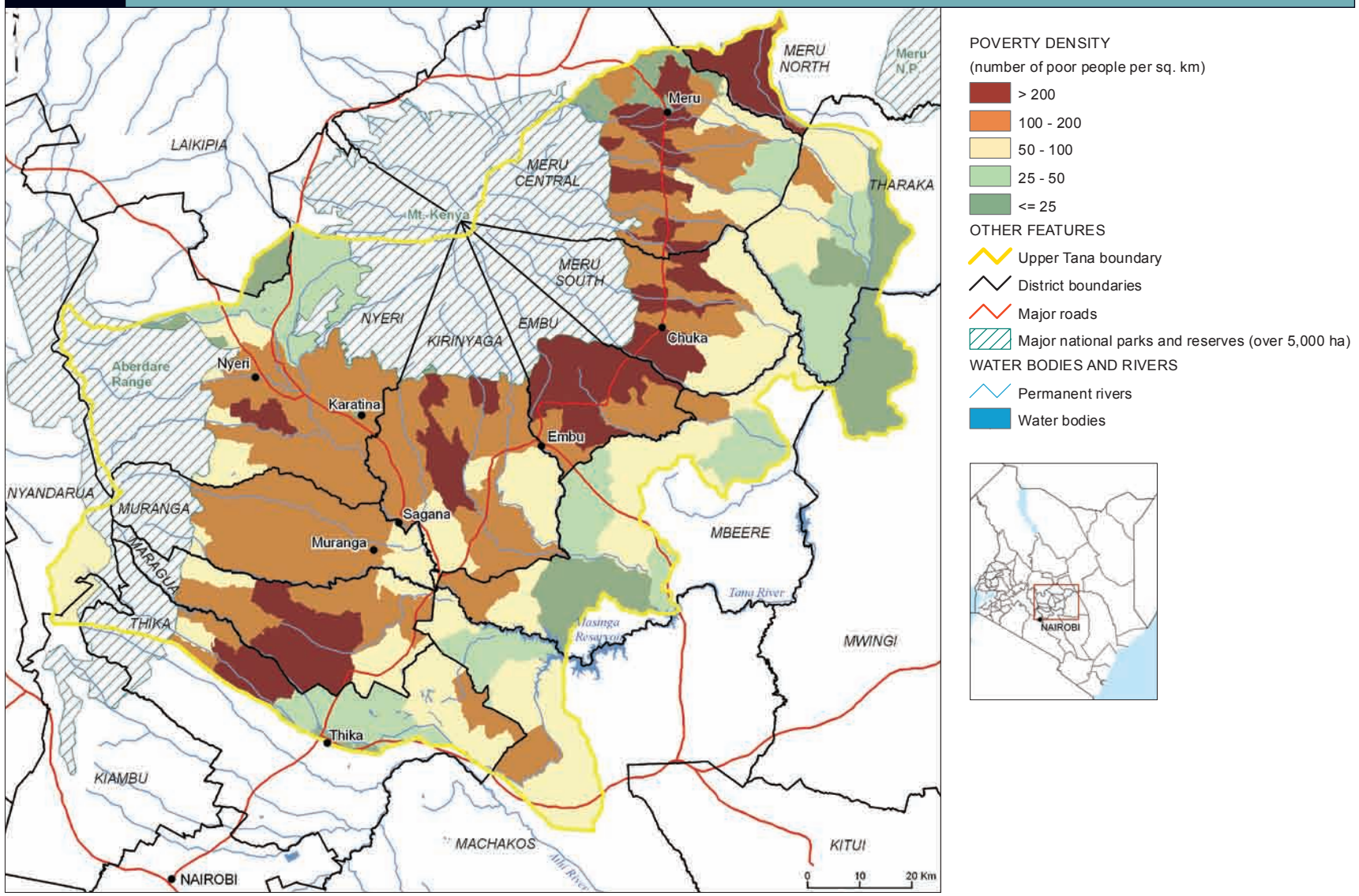
Spatial patterns of poverty in the upper Tana are quite distinctive. Along the rivers that drain the Aberdare Range or Mount Kenya, Locations at higher elevations in general have lower poverty rates than the Locations further downstream.

The communities in the lower plains and the drier parts of the upper Tana have the highest poverty rates (shown in two shades of brown on Map 8.3), which are above the national rural average of 53 percent. The better off region, which contains large contiguous areas where the poverty rate is less than 35 percent (shown in dark green), is located in the foothills of Thika, Maragua, Muranga, Nyeri, and Kirinyaga Districts.

Poverty rates in the remaining three foothill Districts of Mount Kenya—Meru Central, Meru South, and Embu—reflect a more mixed picture. They are generally higher than those in foothills further west, including the slopes of the Aberdare Range. Communities in Meru Central, on average, do better than those in Meru South and Embu Districts. Meru Central includes quite a number of administrative areas with relatively low poverty rates, most of them close to the town of Meru. The spatial patterns of poverty in Embu and Meru South Districts resemble those of communities in the drier plains.

Spatial patterns of *poverty density* (Map 8.4) are quite different from those of *poverty rates*. Despite the very high poverty rates in the lower plains, the poverty density (that is, the number of poor people per square kilometer) is generally quite low in many of these dry, sparsely populated areas (see Map 8.4, areas colored in green). In contrast, some communities with the highest poverty densities (areas colored in dark brown, with more than 200 poor people per square kilometer) are located in densely populated areas with relatively low poverty rates. This reflects the situation in the nation as a whole (see Map 2.4 and Map 2.5 in Chapter 2). Map 8.4 is a reminder that analyses of spatial poverty patterns or program targeting cannot rely on poverty rates alone. That approach may overlook communities such as some spots in Maragua and Nyeri Districts that have a high number of poor, averaging more than 200 poor persons per square kilometer, but only show average poverty rates of 35–45 percent.

Map 8.4 Upper Tana: Poverty Density, 1999



Sources: See Map 2.7.

WATER-RELATED ECOSYSTEM SERVICES

Chapter 3 examined key water issues and spatial patterns of water-related ecosystem services at a national level. Many of these issues are particularly relevant for the upper Tana. For the purposes of this section, we closely examine indicators related to drinking water and irrigation conveyed in the maps of Chapter 3. To highlight the multiple demands on freshwater systems in the upper Tana, this section also shows other uses of water such as hydropower, large inter-basin transfers to supply urban areas, and water for nature (i.e., to maintain wetlands and other natural habitats both within and outside protected areas).

While much of the country experiences marginal rainfall and conditions of general water scarcity, the Kenyan highlands, including the foothills of the upper Tana, receive ample rainfall and are relatively water-rich. The lower elevations of the upper Tana, however, receive less rainfall, making growing crops a more precarious pursuit and grazing livestock a safer bet.

Key water uses in the upper Tana include water used for agricultural production, electricity generation, household drinking supply, and maintenance of wildlife habitat. In many ways, the importance of the area's water resources takes on a national significance which transcends the value of the resources to just the Tana region itself. A large share of the nation's agricultural production occurs here, including crops for export. Hydroelectricity generated by the region's rivers is the principal electricity source for the country. And drinking water supplies from this basin are essential for Nairobi's population.

Water is also important for maintaining healthy wildlife habitats. The need to support nature-based tourism and to sustain Kenya's biodiversity thus requires a basin-wide management approach to ensure that wetlands and other habitats have enough water.

Population growth and economic development put heavy pressure on Kenya's water resources in general, especially in the upper Tana. Water demand is likely to continue to grow as urban populations rise and as the proportion of households with access to piped water increases.

Indicators Examined

The following analyses overlay maps of poverty with different water uses, making use of two water-related indicators:

- *Share of households relying on piped drinking water.* Households that benefit from piped drinking water are in theory somewhat buffered from interruptions in the quality or quantity of water (assuming well-functioning water delivery and treatment systems). Comparing poverty rates and the level of access to piped water can help identify communities that have both high poverty rates and no piped drinking water supplies. We also expect that more affluent communities are more likely to have a higher share of households relying on piped water, mostly because these communities have more resources and perhaps greater political influence to attract water infrastructure investments.
- *Presence of small-scale irrigation efforts within communities.* The presence of small-scale irrigation efforts represent investments made to generate economic benefits from increased crop productivity and to reduce vulnerability to crop failures. The purpose of overlaying poverty and small-scale irrigation efforts is to examine whether investments in small-scale irrigation have reached both poor and more affluent communities. It also highlights areas in which these investments are lacking, thus limiting livelihood options for households or making them more vulnerable to crop failure. Because of their low capital requirements, we expect small-scale irrigation efforts to be distributed throughout the upper Tana and to reach a significant share of poor communities.

The final overlay analysis in the following section examines to what degree communities with a high share of piped drinking water and communities with small-scale irrigation efforts coincide. This comparison is not so much an investigation of possible causal relationships between these two indicators. It is more to locate areas that have benefited from both types of water infrastructure investments, thus enhancing the benefits from water-related ecosystem services and buffering local livelihoods from interruptions in these services. We expect small-scale irrigation efforts to be more widely dispersed than the communities with high shares of piped drinking water sources.

Drinking Water Use and Poverty

As shown in Map 8.5, the majority of the population of the upper Tana obtains drinking water from untreated surface water, groundwater, or a combination of surface and groundwater. In areas where more than 75 percent of households depend exclusively on surface waters (shown in red), people obtain their water directly from lakes and streams or from reservoirs and ponds. In the upper Tana, such areas are mostly located in the foothills of the Aberdare Range or Mount Kenya as well as at lower elevations in the plains closer to the Tana River and its reservoirs.

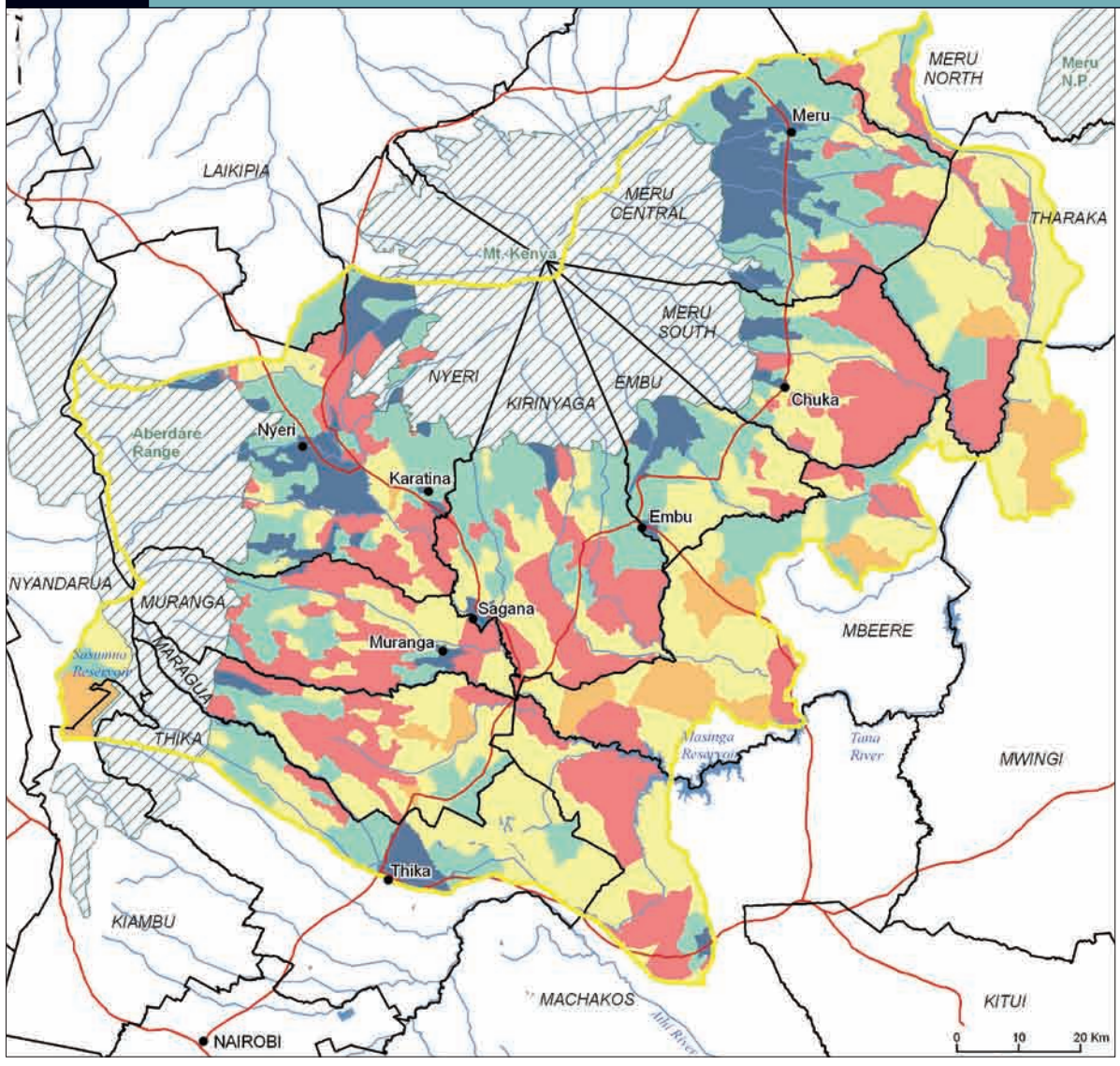
Households that use surface water for drinking are particularly vulnerable to problems posed by insufficient quantity and quality of water. The quantity of surface water available at any given time depends directly on natural flows of water and the patterns of rainfall that generate these flows. Dependence on surface waters also implies direct reliance on ecosystems for their natural waste removal capacity, such as filtering by wetlands and the dilution capacity of freshwater systems.

Areas in which more than 75 percent of households depend solely on groundwater for their drinking water are shown in Map 8.5 in orange. Here people use springs, wells, and boreholes to obtain water. Such areas are located mostly in the lower plains and drier areas of the Tana headwaters. These communities are likely to be somewhat less vulnerable to water quality problems due to greater natural filtering of groundwater supplies.

Areas where more than 75 percent of households receive piped drinking water are shown in dark blue. These populations are more indirectly linked to their ecosystem and in theory could rely on modern methods of municipal water treatment to insulate them from vulnerability to drinking water contamination. They are clustered in more densely populated areas, including the towns of Nyeri, Thika, Embu, Chuka, Meru, and surrounding locations.

Map 8.6 highlights poverty rates (data are shown by Location) in communities with high access to piped water systems (more than 75 percent of households obtain their drinking water from piped water supplies). As expected, communities with a

Map 8.5 Upper Tana: Household Reliance on Ecosystems for Drinking Water



SINGLE DOMINANT DRINKING WATER SOURCES
- More than 75% of households rely on surface water
- More than 75% of households rely on groundwater
- More than 75% of households rely on piped water

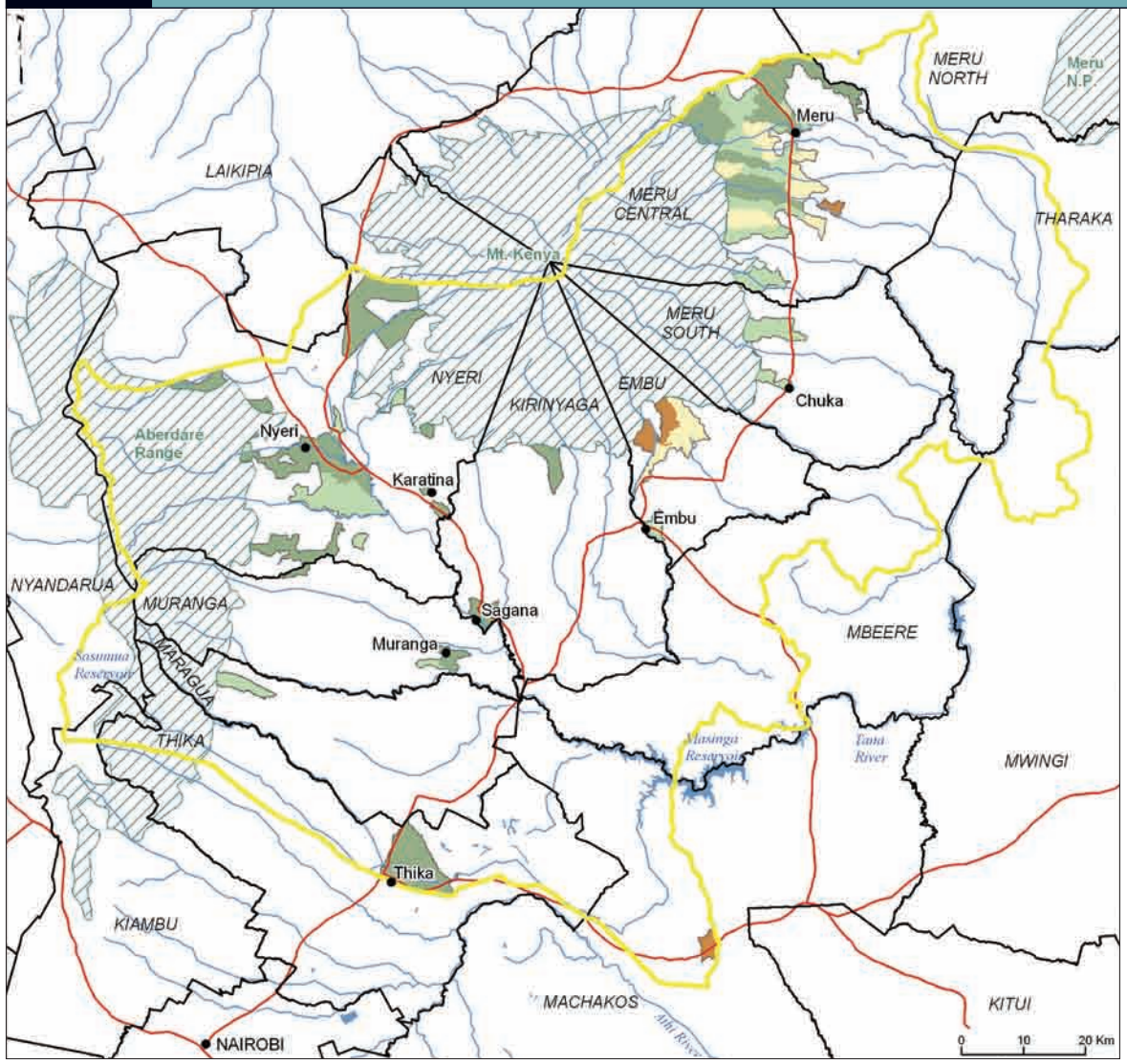
MIX OF DRINKING WATER SOURCES
- More than 75% of households rely on surface and groundwater
- Mix of piped, surface, and groundwater with no dominant source

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

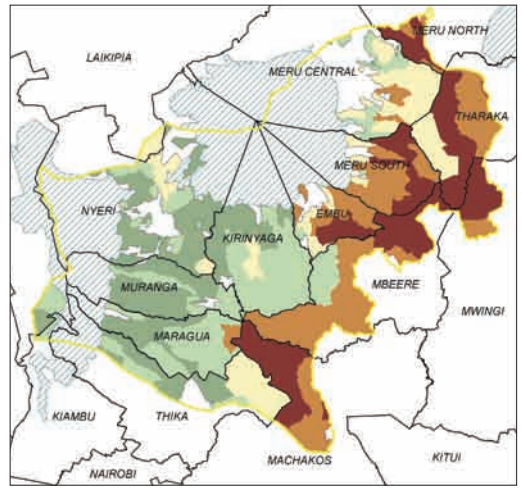
Sources: See Map 3.8.

Map 8.6 Upper Tana: High Share of Piped Drinking Water and Poverty Rate



Sources: See Map 2.6 and Map 3.8.

Poverty Rate in Areas with Piped Drinking Water Access Below 75 Percent or Other Source



POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

high share of piped drinking water are few in number, are spatially concentrated, and have low poverty rates. These communities are located in administrative areas near the towns of Nyeri, Meru, and Thika as well as in Locations in northern Nyeri, Kirinyaga, and Meru Central Districts with poverty rates below 35 percent (shaded in dark green). Locations south of the town of Nyeri, near the town of Embu, and in Meru Central and Meru South Districts have poverty rates of 35–45 percent (colored light green).

The poorest areas in the upper Tana have not benefited from investments in piped drinking water, as the lack of brown areas in Map 8.6 indicates. There are, however, a few exceptions. For instance, some Locations with a high share of piped water systems have poverty rates of 45–55 percent (shaded yellow) and even 55–65 percent (shaded light brown), mostly in Meru Central and in Embu Districts. Further analysis could investigate why piped water investments in these poorer communities were possible and whether the well-being of poor households in a community with higher piped water supplies has improved (for example, resulting in fewer cases of childhood diarrhea and more time for girls to attend school).

Although most areas with high access to piped drinking water have relatively low poverty rates, this does not imply that all Locations with low poverty have high access to improved water sources (see small inset map showing poverty rates for areas with piped water access below 75 percent, or other drinking water sources). Indeed, some Locations with quite low incidence of poverty—including extensive areas in the Aberdare foothills in Thika, Maragua, Muranga, and Nyeri Districts—have no or low access to piped drinking water (that is, fewer than 10 percent of households obtain their water from piped water systems).

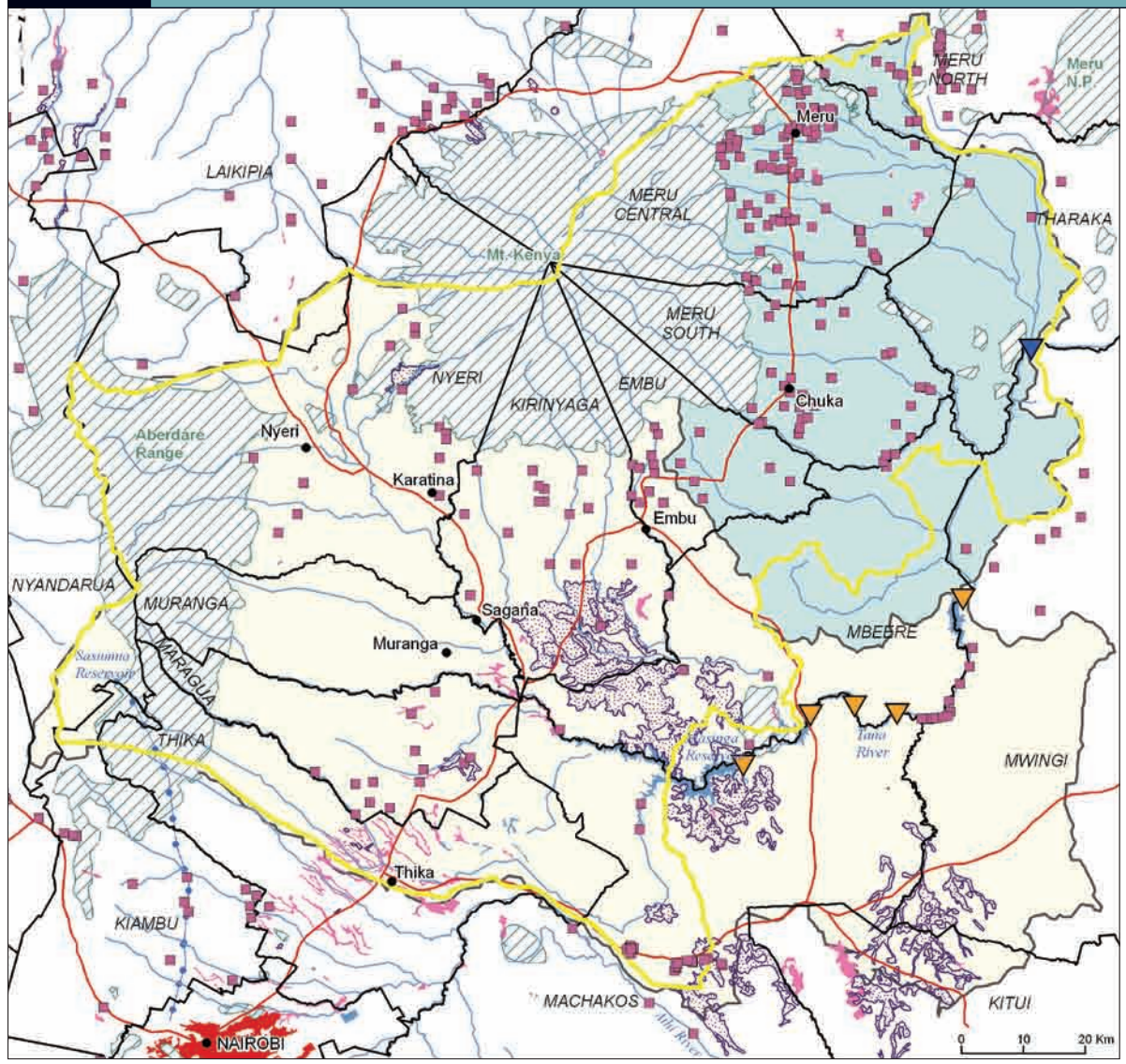
Irrigation Efforts, Other Water Uses, and Poverty

Map 8.7 provides an overview of irrigation efforts in the upper Tana. Large-scale irrigation projects, shown with purple shading, include the Mwea-Tebere rice irrigation scheme, which covers some 6,100 hectares in Kirinyaga and Mbeere Districts. Small-scale irrigation, indicated by pink squares, is mostly located farther upstream on the Tana River tributaries. Many of the small-scale irrigation points serve horticultural crops, including fruit and vegetables. Most of these are concentrated at the base of Mount Kenya in the Districts of Meru Central and Meru South, as well as in Embu, Kirinyaga, and Nyeri Districts. Farmers in the foothills of the Aberdare Range rely less on small-scale irrigation, with only a few such projects, mostly located in Maragua District between the towns of Thika and Muranga.

Irrigation is only one of many water uses in the upper Tana. As shown in Map 8.7, there are multiple demands on freshwater systems in this region. Water with a low sediment content is needed for generation of energy (indicated by the shaded catchments that feed electricity-generating dams). The upper Tana region also has to handle significant water transfers to the Athi River basin and supply drinking water to Nairobi (as indicated by one of the major pipelines that connects the Sasumua reservoir to Nairobi). Water is also needed for environmental services, an often overlooked use of water resources in the region, and is represented on the map as wetland remnants and protected areas.

Due to intensive cropping patterns, very few areas of large, contiguous wetlands remain in the upper Tana. Wetlands (shown as pink-shaded areas) are located within a few kilometers of the towns of Thika and Muranga and near the boundaries of Meru National Park. In the coming years, these wetland remnants will likely face growing pressure from rising demands for land and water. Policymakers may have to consider difficult tradeoffs—for instance, whether to allow conversion of these wetlands for irrigated crop production, or to protect them in their natural state so that they can filter runoff from intensively farmed slopes and provide habitat for wildlife.

Map 8.7 Upper Tana: Irrigation Efforts and Other Water Uses



IRRIGATION INFRASTRUCTURE
- Small-scale irrigation points
- Large-scale irrigation

HYDROPOWER INFRASTUCTURE
- Existing hydropower sites
- Proposed hydropower sites

IMPORTANT LAND COVER FEATURES
- Wetlands
- Urban areas

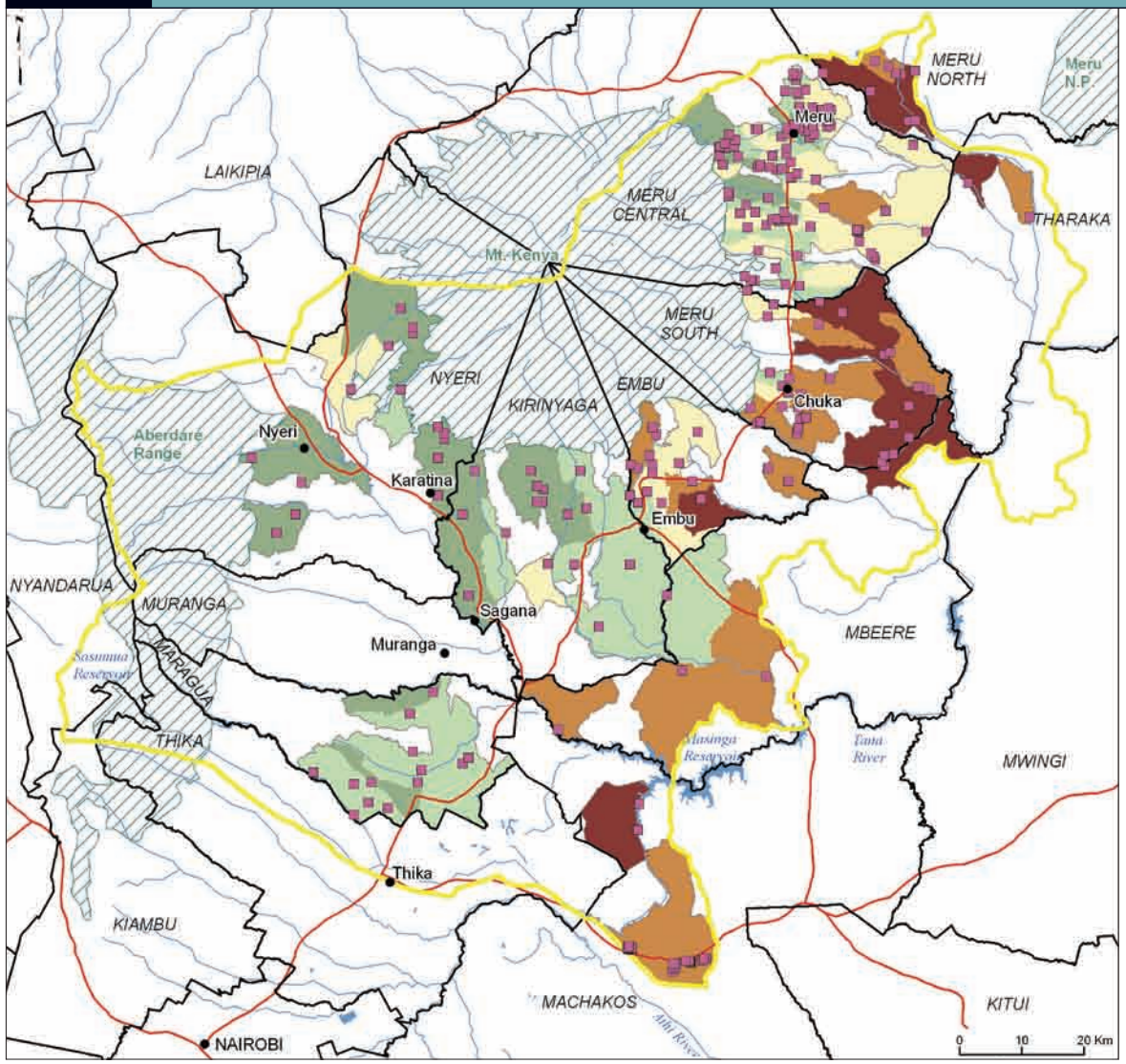
IMPORTANT DRAINAGE AREAS
- Drainage area upstream from existing dams
- Drainage area upstream from proposed dams

OTHER FEATURES
- Upper Tana boundary
- Sasumua pipeline
- District boundaries
- Major roads
- National parks and reserves

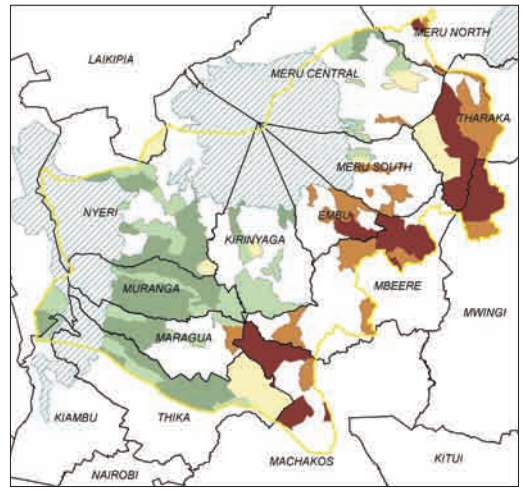
WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 3.9, Map 3.11, Map 3.12, and Map 5.3.

Map 8.8 Upper Tana: Small-Scale Irrigation Efforts and Poverty Rate



Poverty Rate in Areas Without Small-Scale Irrigation Efforts



IRRIGATION INFRASTRUCTURE
- Small-scale irrigation points

POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 2.6 and Map 3.12.

The overlay analysis in Map 8.8 focuses on small-scale irrigation efforts because they are more widely dispersed throughout the upper Tana and require comparatively small investments, which means they can reach poorer areas and households more easily. Large-scale irrigation in the upper Tana is concentrated in a contiguous area in lower Kirinyaga and southwestern Mbeere Districts.

Map 8.8 indicates that most small-scale irrigation sites ring Mount Kenya at similar elevations and with comparable rainfall. They also reach the plains, notably in Meru South, Machakos, and Meru North Districts. In these drier areas, however, they are much lower in number and density. Compared to the map showing high shares of piped drinking water, communities with small-scale irrigation efforts are widely dispersed.

As expected, poverty rates in areas with investments in small-scale irrigation vary considerably, from Locations with quite low poverty rates (less than 35 percent) in Nyeri and Kirinyaga Districts to those with very high poverty rates (55 to 65 percent) farther east. Of all the small-scale irrigation efforts, it is those in Meru North, Machakos, and Meru South Districts that are generally in the poorer administrative areas, with poverty rates averaging 55 percent and higher. The irrigation efforts in Nyeri District are in administrative areas with much lower poverty rates, as is the case for those in the Aberdare foothills.

Map 8.8 confirms that some of the poorest communities in the upper Tana have benefited from small-scale irrigation efforts (albeit at lower numbers). Subsequent analysis focusing on these areas can pinpoint where small-scale irrigation investments have lowered poverty rates versus those areas where their contributions have not been large enough to significantly affect household income, but perhaps have increased nutritional status and food security. This could then help in targeting other poor communities in the drier lowlands, since a significant number of these communities have not benefited from small-scale irrigation yet (as can be seen in the small inset map).

High Share of Piped Drinking Water and Small-Scale Irrigation Efforts

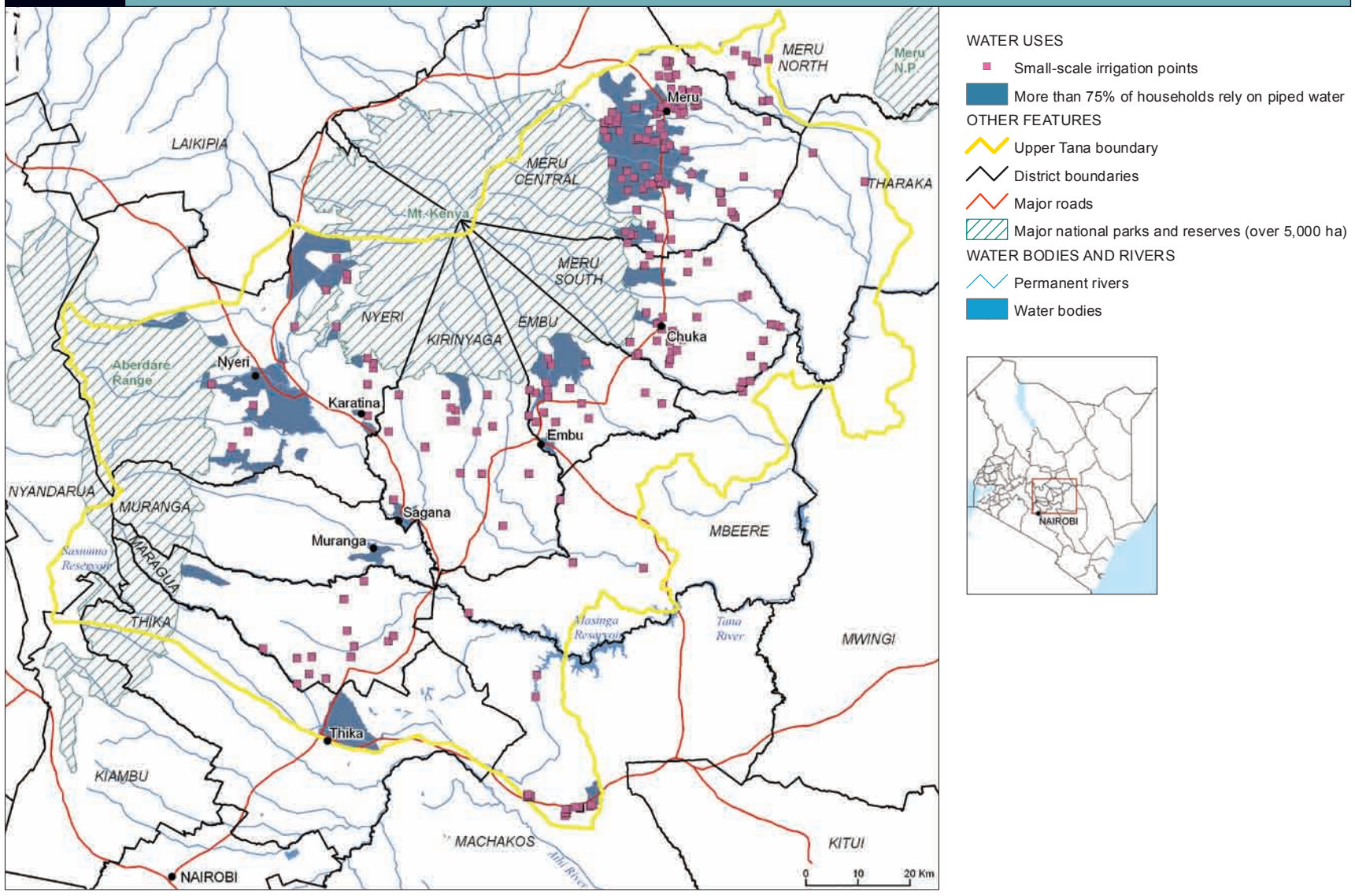
Most communities with a high share of households relying on piped drinking water are in the more densely populated urban areas and in rural areas at higher elevations bordering the forest zone and protected areas. Meru Central District has the greatest number of rural communities with a high share of piped water access. There are still significant opportunities for investing in improved drinking water supplies throughout the upper Tana, especially where there are high rural population densities such as upper Kirinyaga and Maragua Districts (see Map 8.2 for population densities).

The foothills of Mount Kenya have the greatest number of small-scale irrigation points. Meru Central District has the greatest concentration of small-scale irrigation efforts in the upper Tana (about 40 percent of the mapped irrigation points). Meru South, Nyeri, and Machakos Districts have similar shares (around 10 percent each) of the mapped irrigation points. Only a handful of small irrigation points are located in the drier areas of Tharaka and Mbeere Districts.

The degree of spatial overlap between investments in small-scale irrigation and piped water systems varies considerably across the upper Tana. In some areas, these investments coincide, but in others they do not. For instance, in Meru Central District there is extensive coincidence of small-scale irrigation efforts and piped drinking water systems. In Meru South and Embu Districts, some overlap exists, but to a much lesser degree than that seen in Meru Central. In other Districts, however, areas with high access to piped drinking water (for example, in Nyeri, Kirinyaga, Maragua, and Thika Districts) do not show any overlap with investments in small-scale irrigation.

Examining the history of these investments and the adaptation of small-scale irrigation technology in more detail may reveal why Meru Central has benefited to a greater degree from both small-scale irrigation and piped drinking water supplies. Such an investigation could point toward possible synergies between investing in piped water systems and establishing small-scale irrigation efforts that could be instructive for neighboring Districts.

Map 8.9 Upper Tana : Small-Scale Irrigation Efforts and High Share of Piped Drinking Water



Sources: See Map 3.8 and Map 3.12.

FOOD-RELATED ECOSYSTEM SERVICES

As described in previous chapters, Kenya's croplands are concentrated in areas of reliable rainfall, including the upper Tana. Kenyan farmers grow a mixture of food and cash crops, including tea, coffee, sugarcane, tobacco, and sisal. The foothills of the Aberdare Range and Mount Kenya are an important food and cash crop supplier, with some of the longest established tea- and coffee-growing areas in the country. Over the past decade, the upper Tana has also become an important supply area of vegetables and flowers, both for export and domestic consumption.

The dominant land use for the upper Tana is smallholder agriculture. While a large number of Kenyan smallholders still grow food crops for subsistence, recent data show the growing importance of cash crops for household income. Farming families are increasingly relying on cash income and the market economy for food security (Jayne et al. 2000).

A large percentage of farming households in the foothills of the upper Tana own cross-bred dairy cattle. The animals are raised in stalls and fed cut grass, tree leaves from fodder trees, or even purchased commercial feed.

Since the soils are fertile and rainfall is more reliable in these foothills, farmers crop the available land intensively. However, because of population growth and increased subdivision of farms since Kenya's independence, average farm size has decreased, making it difficult or impossible to support a family in some areas. A longitudinal study of land use patterns since the 1950s on the eastern slopes of Mount Kenya (Embu and Mbeere Districts) found that this has prompted family members of richer

households to purchase or rent land in the more marginal cropping areas at lower elevations. Other responses include investment in children's education, migration to urban areas such as Nairobi, and employment in the non-agriculture sector (Olson 2004).

Kenya's *Economic Recovery Strategy for Wealth and Employment Creation 2003–2007* (GoK 2003) seeks major reform of agricultural policies and institutions to reverse the decline in agricultural growth and productivity over the past decade. The upper Tana will be both a key region impacted by these reforms and an important pillar for future agricultural growth.

Indicators Examined

This section relies on two indicators introduced in Chapter 4 to examine the region's food crops and dairy cattle—the two major sources of food from agriculture:

- *Share of cropland under food crops.* Croplands with a relatively low share of food crops are producing a greater proportion of nonfood crops (especially coffee and tea) for cash or export. Our hypothesis is that this will correlate with lower incidence of poverty. A high share of cropland in food crops—especially when it includes the staple crop maize and very few other crops—could indicate subsistence farming, which is associated with higher poverty rates. But in some areas it corresponds with large-scale, irrigated commodity crops such as rice (upper and lower Tana), mechanized wheat farms (Narok District), high-yielding maize production (Uasin Gishu and Trans Nzoia Districts), or even more complex farming systems that produce a mix of high-value food crops including cereals, vegetables, and fruit trees.
- *Total milk production per area.* Dairy provides a source of high-quality protein and micronutrients, which are often lacking in largely cereal-based diets. Thus, we might expect areas with relatively high levels of milk production to be better off, with a greater concentration of households that can afford better nutrition. Moreover, livestock provide household savings and supplemental income for farming families. A plausible hypothesis, therefore, would be that areas with higher dairy output correlate with lower poverty rates.

For each indicator, we will first provide an overview of the major spatial patterns and then compare high production areas (high share of food cropping and high milk output) with poverty rates. Such a comparison may help formulate additional hypotheses about the relationship between food-related ecosystem services and the level of well-being in a geographic area. It can also be used to contrast areas with similar poverty levels and classify them according to their orientation toward food crops or milk production. This can then support agricultural planning, such as deciding where to target new livestock breeds or crops. In a final step, we will look at spatial overlaps between areas with high food cropping and high milk production. Such an analysis can help to delineate areas with potential conflicts or synergies between food cropping and milk production.

Food Cropping and Poverty

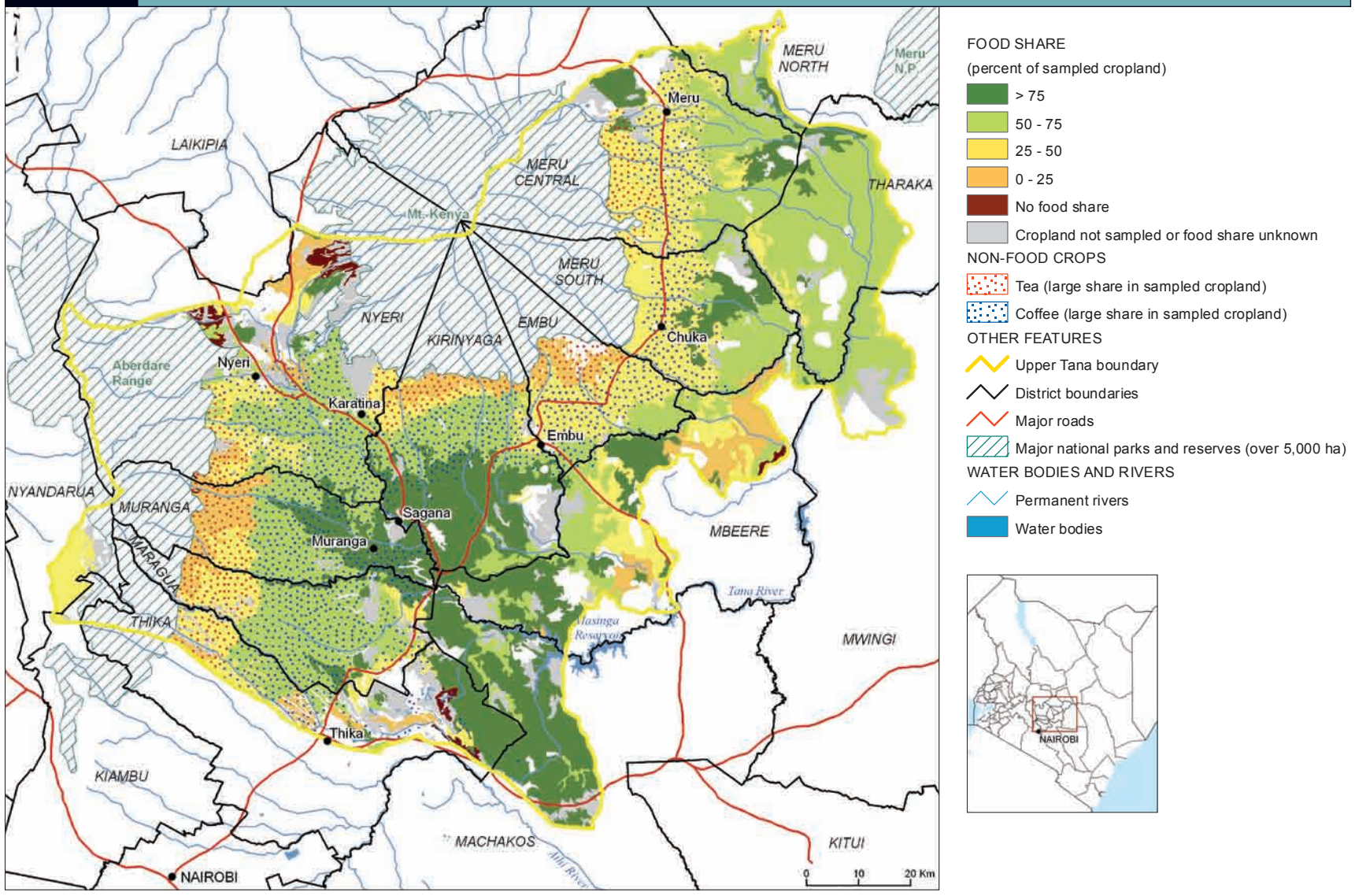
Map 8.10 shows how much of their cropland farmers have dedicated to food crops. The level of food cropping varies significantly across the upper Tana. In general, farmers in the higher-elevation sections of the foothills grow a lower share of food crops.

Most areas with a very high percentage of agricultural production invested in food crops (i.e., greater than 75 percent, shown as dark green) are at lower elevations. These include large tracts of irrigated rice cultivation in lower Kirinyaga and far southwest Mbeere Districts. These areas also cover non-irrigated areas in northwest Machakos and the lower parts of Muranga and Thika Districts. Small clusters of cropland with a high food share are also found farther east in Meru South and Meru Central Districts.

Areas with a greater share of cropland in non-food cash crops (orange- and yellow-shaded areas) are mostly in the foothills of the Aberdare Range or the slopes of Mount Kenya. These areas include the tea-growing zones at the highest elevations of the foothills and the coffee-growing zones on somewhat lower slopes.

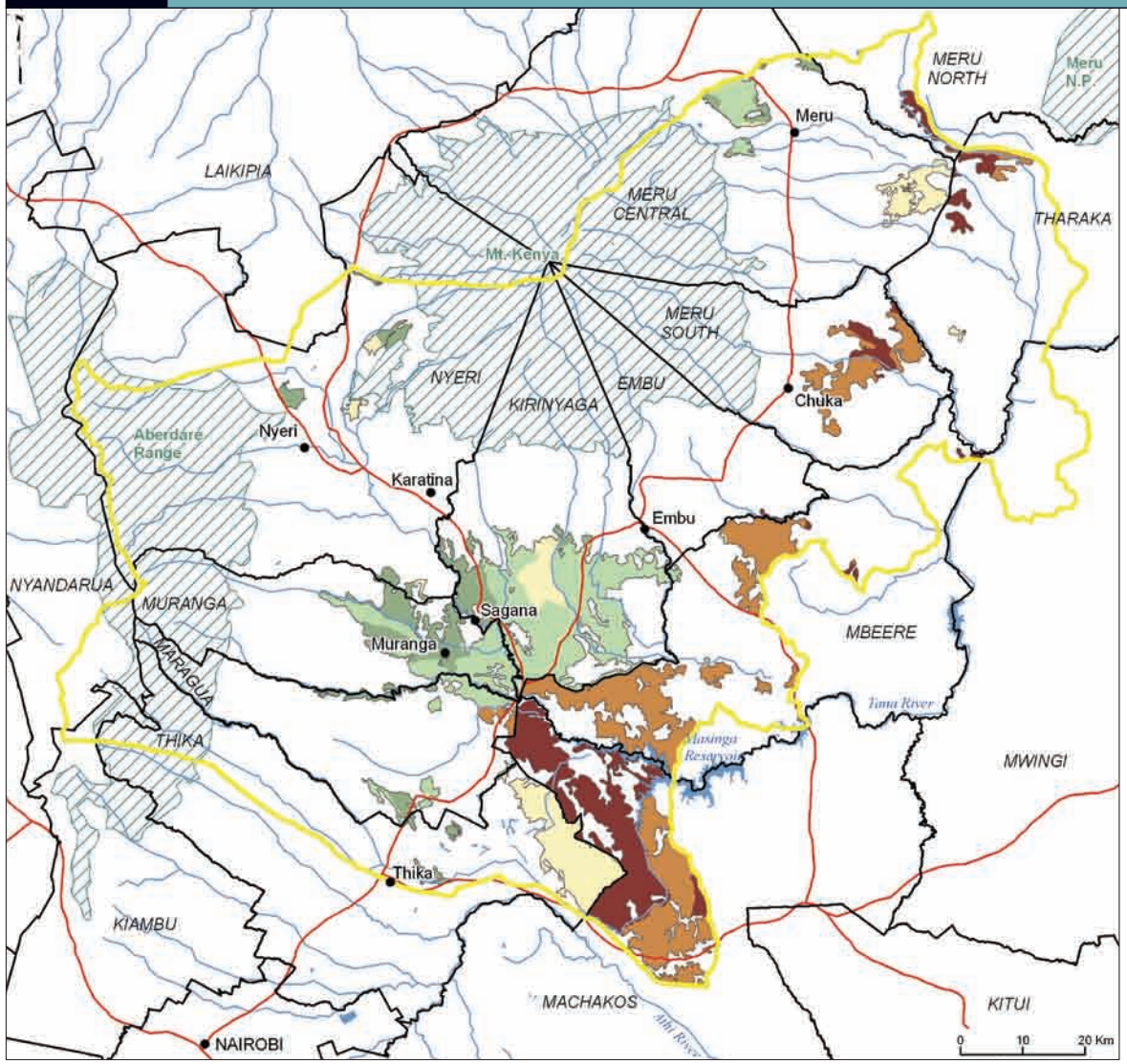
Map 8.11 shows the spatial relationships between poverty (poverty rates are shown by Location) and croplands with a large (i.e., greater than 75 percent) share of production in food crops. Large areas of dark brown—signaling poverty rates of greater than 65 percent—are found in Machakos District and a few Locations in Meru South, Meru North, and Tharaka Districts. Extensive areas of light

Map 8.10 Upper Tana: Food Crops as Percentage of All Cropland

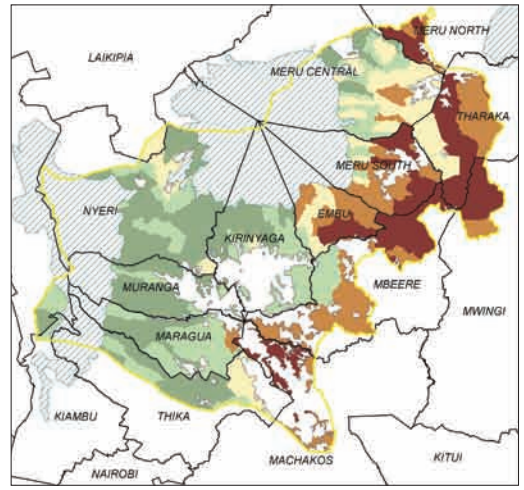


Sources: See Map 4.4.

Map 8.11 Upper Tana: High Share of Food Crops and Poverty Rate



Poverty Rate in Areas with Less than 75 Percent Food Share



POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 2.6 and Map 4.4.

brown (poverty rates of 55–65 percent) are located in Machakos, Mbeere, Meru South, and Tharaka Districts. Areas with low rates of poverty and a high share of food crops (shown in shades of green) are limited to Maragua, Muranga, and Kirinyaga Districts, along with a few Locations in Nyeri and Meru Central Districts.

Areas in the lower drier plains with a high share of food crops consistently have poverty rates above Kenya's national rural average (53 percent). While this would confirm our initial hypothesis, Locations in Kirinyaga and Muranga Districts do not support this simple, straightforward association of high poverty with a high share of food cropping. Similarly, the small inset map (showing poverty rates in areas with less than 75 percent food share) points toward a significant number of high-poverty areas with lower food shares. This suggests that additional information on the number and types of crops grown is required to illuminate the spatial patterns of food cropping and poverty in the upper Tana. For example, while areas in Maragua, Muranga, and Kirinyaga Districts have similar high food shares as areas in northwestern Machakos, Meru South, and southern Meru Central Districts, the types of crops grown and other agricultural factors may differ. In the former three Districts the food crops may include high-value vegetables and other crops destined, via good roads, to reach a large urban market such as Nairobi. In the latter three Districts the share of dryland cereal crops may be greater; the overall value of production may be lower; or the purpose for growing crops may be oriented more toward subsistence and local markets.

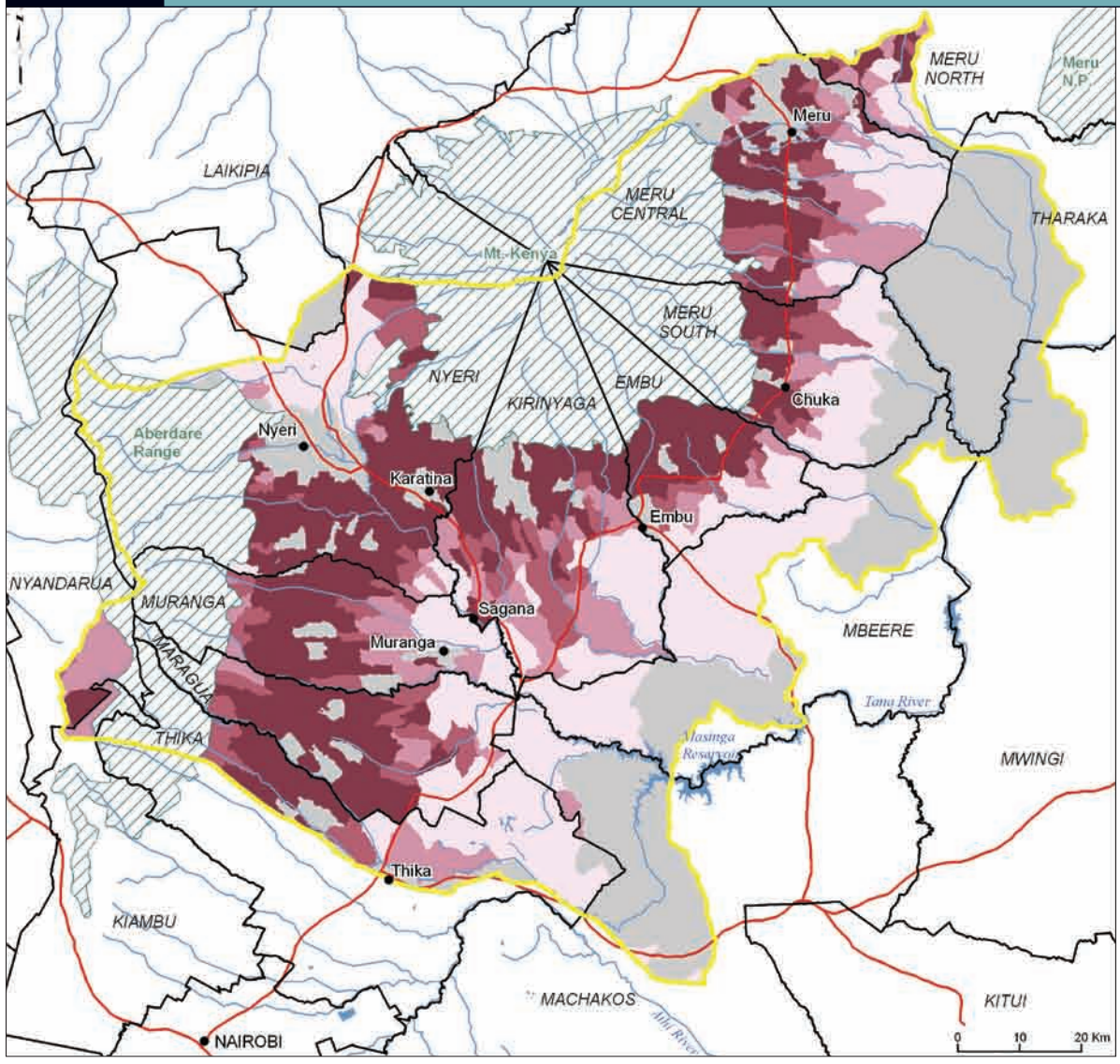
Milk Production and Poverty

Map 8.12 presents the spatial distribution of milk production. Areas with annual milk production greater than 100,000 liters per square kilometer (shaded purple on the map) are mostly at higher elevations in the foothills of the Aberdare Range and Mount Kenya, while areas of low milk production (colored light pink) are at lower elevations.

Map 8.13 shows the spatial coincidence of poverty (poverty rates are shown by Location) and areas with high milk production (i.e., production of more than 100,000 liters per square kilometer per year). Most of these areas are colored in shades of green, corresponding to Locations with a low incidence of poverty. Such Locations form a large expanse across the eastern foothills of the Aberdare Range and the southwestern slopes of Mount Kenya, as well as a few Locations in Meru Central District. Areas with high milk production and relatively greater incidence of poverty (greater than 55 percent) encompass comparatively few Locations. A cluster of such Locations is found in Embu District, as well as a few Locations in Meru South, Meru Central, and Meru North Districts.

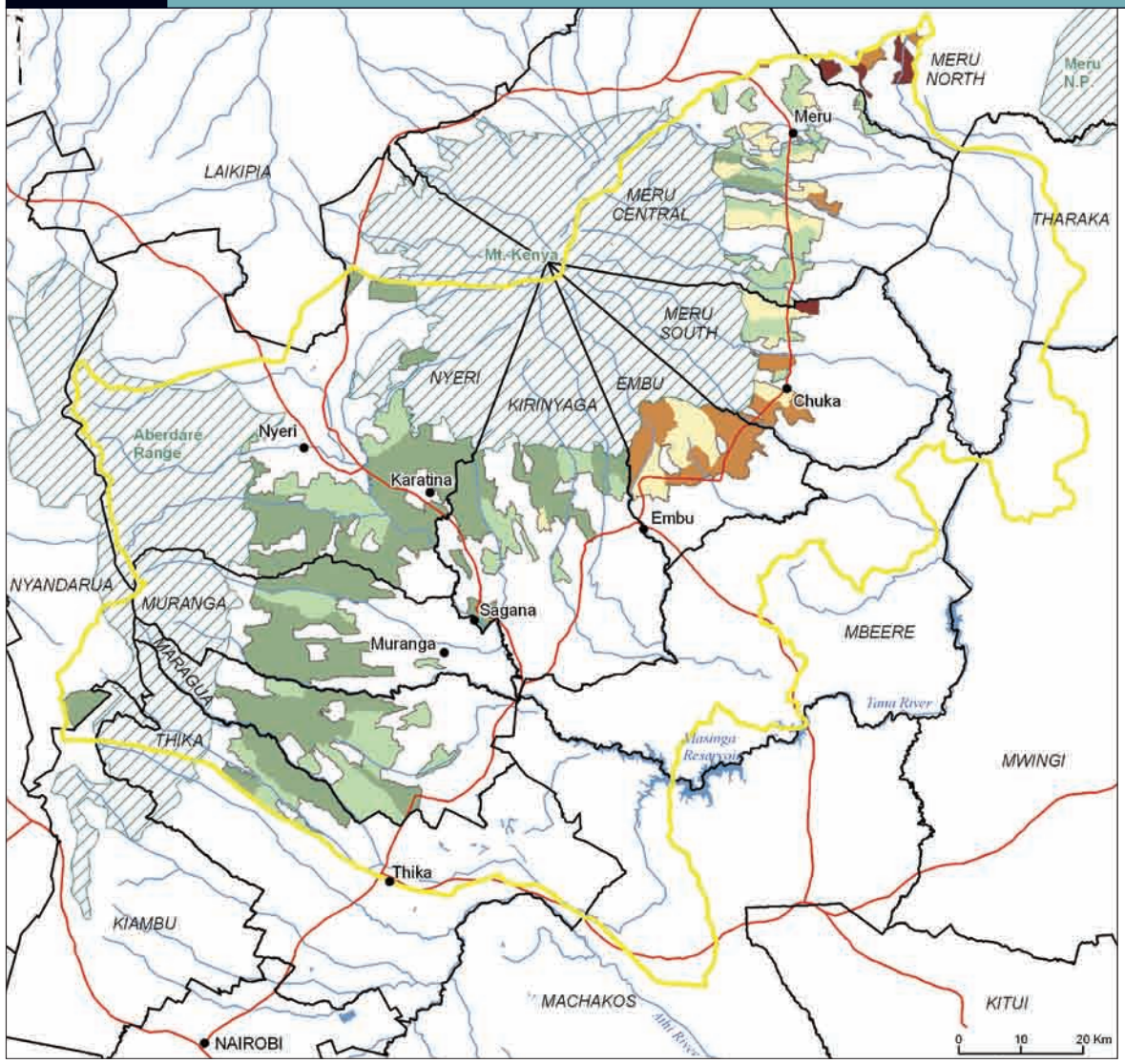
The poverty pattern for most Locations with high milk production supports the hypothesis that high milk output—most likely associated with a greater number of cross-bred dairy cattle—is more prevalent in communities with lower poverty rates. This is also supported by the small inset map (showing poverty rates in areas with less than 100,000 liters per square kilometer per year), which indicates significant overlap between areas with very high poverty rates and areas with the lowest milk output

Map 8.12 Upper Tana: Milk Production

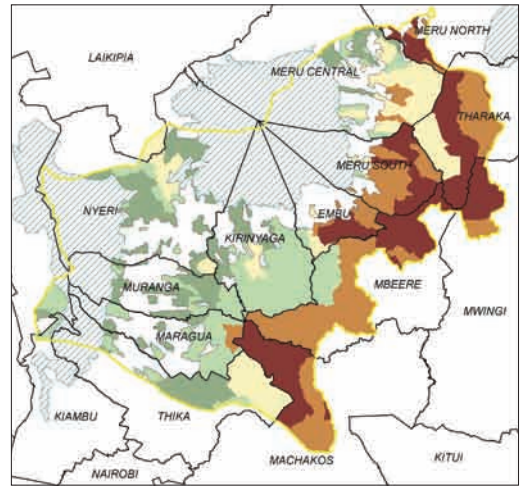


Sources: See Map 4.5.

Map 8.13 Upper Tana: High Milk Production and Poverty Rate



Poverty Rate in Areas with Less than 100,000 Liters per Square Kilometer per Year



POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 2.6 and Map 4.5.

(Map 8.12). Further investigation is needed to understand causal relationships and determine whether households became less poor once they became high milk producers or whether a certain amount of capital had to be in place to support a high-milk output production system.

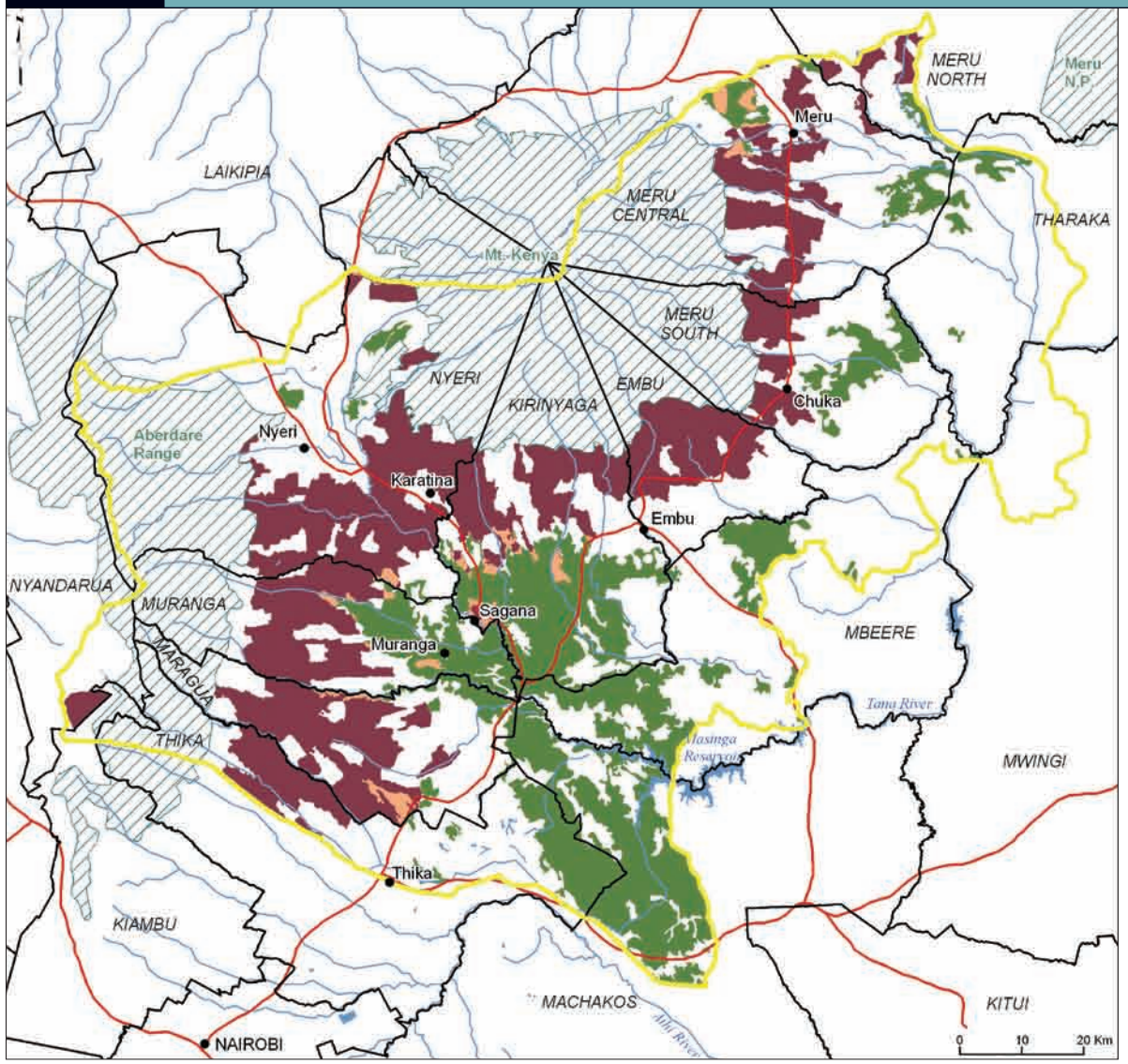
The high-poverty and high-milk output areas in Embu District appear to contradict our initial hypothesis above. Further analysis of these areas is required to unmask the reasons why these poorer communities are such high milk producers or why higher milk output has not lowered overall poverty rates. For example, farmers may be high producers but their income may be lower because of failures in the milk market. Or farmers in the Aberdare Range may have additional and more diversified income streams than high milk producers in Embu. Such a detailed analysis could provide useful insights into the causes of high poverty rates. It could also help promote appropriate milk production technology in poorer communities in the upper Tana, for example in Meru South District.

High Food Cropping and High Milk Output

As seen in Map 8.14, there is very little spatial overlap between areas with a high share of food crops and areas with high milk production. While areas of high milk production (shaded purple on the map) form a large expanse across the eastern foothills of the Aberdare Range and the southern and eastern slopes of Mount Kenya, areas with a high share of food crops (colored green) stretch across low-elevation locations in Machakos and southern Kirinyaga Districts. Only a small number of locations (shown in orange) are intensive producers of both food crops and dairy. These areas of overlap are concentrated across the midsection of Kirinyaga District, as well as a few locations in Maragua, Muranga, Nyeri, and Meru Central Districts.

This lack of spatial overlap in Map 8.14 suggests two different livelihood strategies for farming families in the upper Tana: farmers higher up in the foothills (and to a much larger degree in the Districts east of the Aberdare Range) rely more on nonfood cash crops and high milk outputs for their income than their counterparts further downstream. Farmers at lower elevations are focused more on food crops, and the milk output per unit area in these lowlands is less. Investigating the underlying reasons for this difference—for example, less productive indigenous breeds of dairy cattle, fewer high-yielding cross breeds per area, or a less developed system for transporting and processing milk in the lowlands—could reveal where boosting milk production may improve livelihoods and well-being.

Map 8.14 Upper Tana: High Share of Food Crops and High Milk Production



MAIN PRODUCTION AREAS
- High food share
- High milk production
- High food share and high milk production

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: Map 4.4 and Map 4.5.

BIODIVERSITY- AND WOOD-RELATED ECOSYSTEM SERVICES

The selected upper Tana watersheds contain some of Kenya's largest tracts of indigenous forest on Mount Kenya and the Aberdare Range. Almost all of these forests are on government land—either a forest reserve or a national park set up to safeguard biodiversity or hydrological services. The area surrounding the forests of the upper Tana is densely populated and there is intensive agricultural production in the foothills of the two mountain ranges.

Over the past 200 years, much of the land in the foothills that once was forest or a mosaic of forest and other habitats has now been cleared and converted to agriculture. This has resulted in significant losses of biological diversity. For instance, most large mammals, such as large wild cats, have become rare. Elephants—which once roamed widely throughout the foothills, taking advantage of greater water availability and feed during the dry season—have retreated to protected areas or less intensively cultivated areas due to habitat loss and wildlife fences that safeguard crops and people. However, the remaining highland forests continue to provide habitat for a disproportionate share of Kenya's total biological diversity, including 50 percent of plant species, 40 percent of mammals, 35 percent of butterflies, and 30 percent of birds (KFWG 2001).

In addition to providing food and other crops, the farmlands in the foothills are an important source of wood, mostly because the remaining indigenous forests are legally protected from large-scale wood removal. Currently, at the household level, farms and woodlots in Kenya provide about two thirds of firewood for domestic use (MoE 2002).

Agricultural landscapes in the foothills also have a role to play in conserving the rich diversity of lifeforms of the Kenyan highlands. The extent to which croplands contribute to biodiversity conservation depends on how people use the land and the resulting impact on its suitability as habitat for native plants and animals. As mentioned in Chapter 5, large monocultures provide a less suitable habitat than clusters of small fields growing multiple crop species (so-called polycropping) within a patchwork of trees, shrubs, and herbaceous plants. The upper Tana is home to landscapes with some of Kenya's highest polycropping, which could contribute to conserving highlands biodiversity.

Indicators Examined

This section makes use of two indicators introduced in earlier chapters:

- *Average number of crops grown in a given farm parcel.* This indicator can be interpreted as a measure of agrobiodiversity. High incidences of polycropping would be associated with higher levels of biodiversity in agroecological landscapes. Polycropping is expected to be more prevalent in the foothills of the upper Tana than in the drier plains at lower elevations. The foothills have more reliable rainfall and a longer growing season and thus provide farmers with more options to plant a greater variety of crops. Farmers may grow different crops simultaneously because the agroclimate permits it, because there is demand for multiple products, or because they want to spread their risk from crop or market failures. We expect polycroppping to be associated with less poverty because livelihoods are based on a better agroecological endowment and more diversified risk strategy. However, not all areas where farmers grow only one or two crops are necessarily marginal farming areas with less rainfall (mostly planted with maize). They can also be highly productive areas where farmers concentrate on a single cash crop.
- *Share of woodlots within croplands.* Mapping the share of woodlots within croplands provides information about where farmlands supply wood and where farmers have made more long-term investments in agroforestry practices. Depending on the tree species and the age of the trees in the woodlot, the wood may serve as firewood, be converted to charcoal, or be used for construction purposes. Areas with less rainfall are expected to have a lower share of woodlots because it will be more difficult to grow trees. Our hypothesis is that higher shares of woodlots in cropland are associated with lower poverty rates—not necessarily because farmers realize higher returns from wood, but because farmers and communities that are better off have a greater financial ability to dedicate some of their land to wood production.

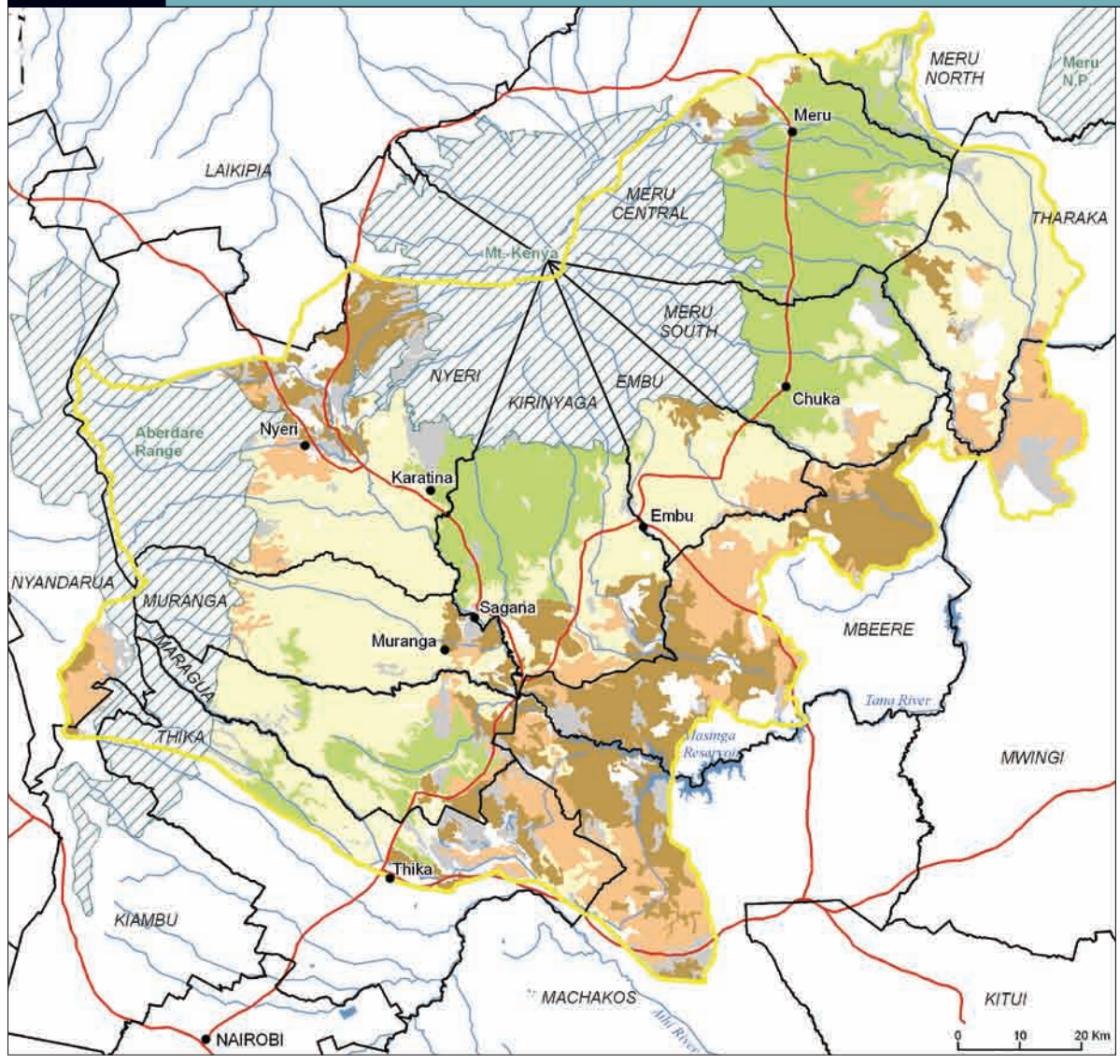
These two indicators, when combined with indicators of the average size of farmers' fields and the extent of tree cover in croplands (as shown in Chapter 5), can provide an overall measure of agrobiodiversity in agricultural landscapes. These measures shed light on the extent to which agricultural land uses and configurations could help relieve pressure on remaining natural forest areas and forest-related biodiversity.

Number of Agricultural Crops and Poverty

Map 8.15 shows the spatial pattern of crop diversity in the farmlands of the upper Tana. Areas where an average of more than four different crop types are being grown simultaneously (shaded green) extend across most of upper Kirinyaga District on the southern slopes of Mount Kenya, as well as in Meru South and Meru Central Districts on the eastern footslopes. A few areas in the lower Aberdare foothills in Thika, Maragua, and Muranga Districts also have relatively high crop diversity levels. Across much of the remaining cropland, especially at higher elevations, farmers grow, on average, two to four crop types in a growing season (yellow areas). Farms located at lower elevations, including rice-growing areas under large-scale irrigation, tend to produce on average one or two crops simultaneously (light brown areas).

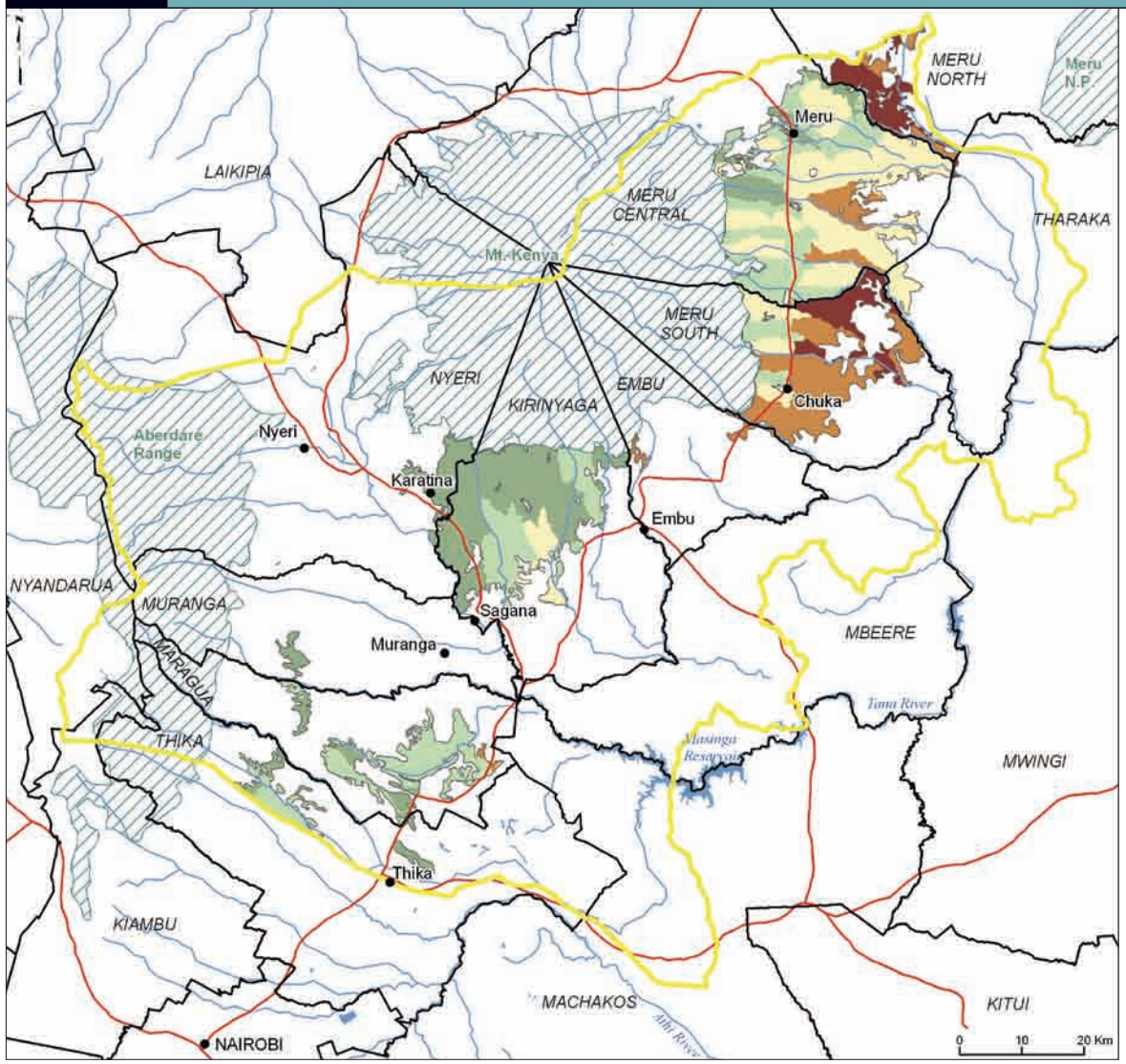
Map 8.15 highlights the extremely diverse cropping patterns in the upper Tana. Landscapes are a patchwork of multiple crops—the majority of them in very small fields. Overall, the farmers on the footslopes of Mount Kenya favor a greater number of crops compared to farmers at similar elevations in the Aberdare foothills (except for a cluster of locations in Thika, Maragua, and Muranga Districts). A closer examination of the types of crops grown, their relative prices, their contribution to safeguarding against possible market risks (price declines) or weather risks (drought or flooding), and institutional and land use policy issues could shed more light on the reasons for this specific spatial pattern.

Map 8.15 Upper Tana: Average Number of Crops Grown in Cropland



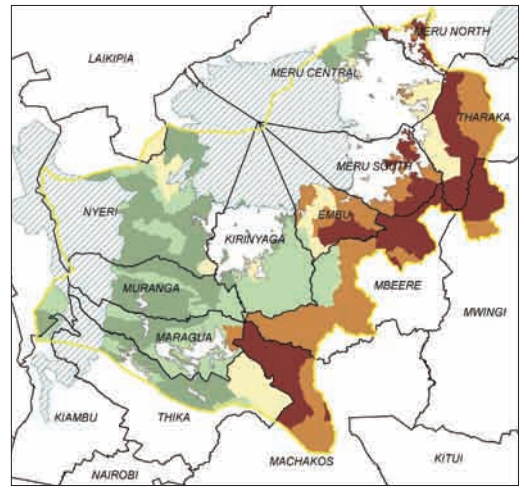
Sources: See Map 5.5.

Map 8.16 Upper Tana: High Average Number of Crops Grown in Cropland and Poverty Rate



Sources: See Map 2.6 and Map 5.5.

Poverty Rate in Areas with Less than Four Agricultural Crops



POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Map 8.16 compares the spatial distribution of areas with high rates of crop diversity (average number of crops is greater than four) with spatial patterns of poverty (poverty rates are shown by Location). Many such high-diversity areas have low poverty rates, including a large expanse on the southern slopes of Mount Kenya in Kirinyaga District, as well as clusters of low-poverty Locations in the foothills of the Aberdare Range, and a few Locations near the town of Meru. However, some areas with high rates of polycropping are found in zones with moderate poverty rates (especially in Meru Central District) as well as in high-poverty areas (in Meru South District).

Further comparison of poverty rates in areas with lower crop diversity (see small inset map showing poverty rates in areas with less than four agricultural crops) indicate that in the Aberdare foothills, very low crop diversity (tea growing areas in Map 8.10) corresponds with very low poverty rates. Inversely, low crop diversity (see Map 8.15) in the drier lowlands (more marginal cropping of maize) corresponds with high poverty rates. This confirms that analysts need to distinguish between marginal and high potential croplands when comparing levels of polycropping and poverty.

High levels of polycropping are therefore not automatically associated with certain poverty rates in the upper Tana. Explaining these spatial patterns of poverty and the number of crops grown will require gathering information on the specific crops being grown and the reasons for selecting them, which could be driven by market demand or household needs for food security.

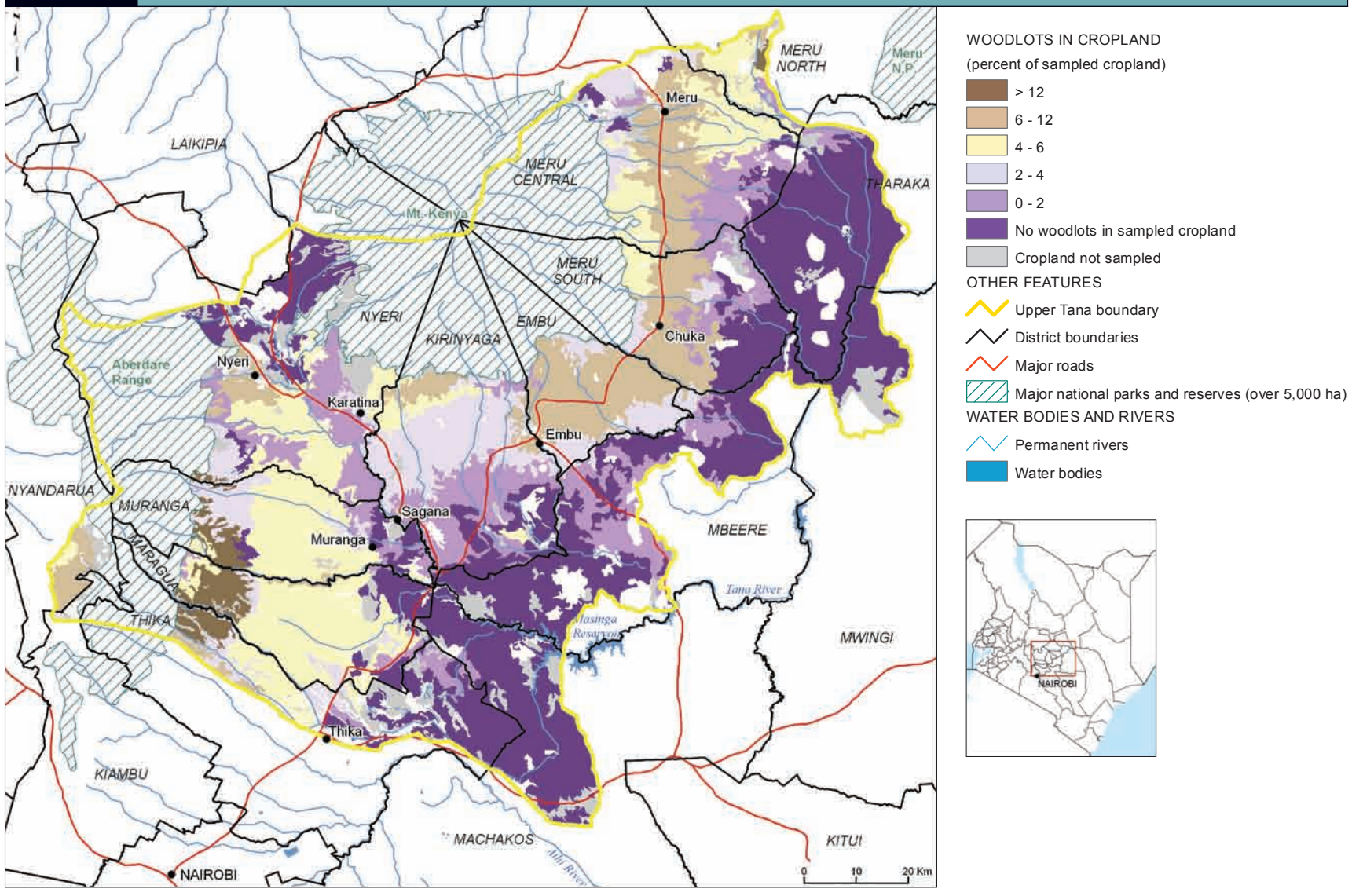
Woodlots in Cropland and Poverty

Map 8.17 shows the share of woodlots in cropped areas of the upper Tana. Areas in which more than 12 percent of the cropland is allocated to woodlots (shown in dark brown), are clustered at high elevations in the Aberdare foothills in Thika, Maragua, and Muranga Districts. A large band of lighter brown, indicating areas in which 6 to 12 percent of cropland is devoted to woodlots, stretches across the foothills of Mount Kenya in Embu, Meru South, and Meru Central Districts. Croplands that contain no woodlots at all (dark purple areas) occur at lower elevations in the drier plains.

Throughout the foothills of the upper Tana, most farmers include wood as one of their crops. A complex set of factors, such as the size of local or urban market demand for wood, availability of labor to grow other more labor-intensive crops, returns on investment of tree crops versus other crops, and even efforts to promote tree planting (e.g., women of the Green Belt Movement), all have to be taken into consideration when analyzing why certain locations in the Aberdare foothills and along the Embu-Meru road have become more significant supply areas.

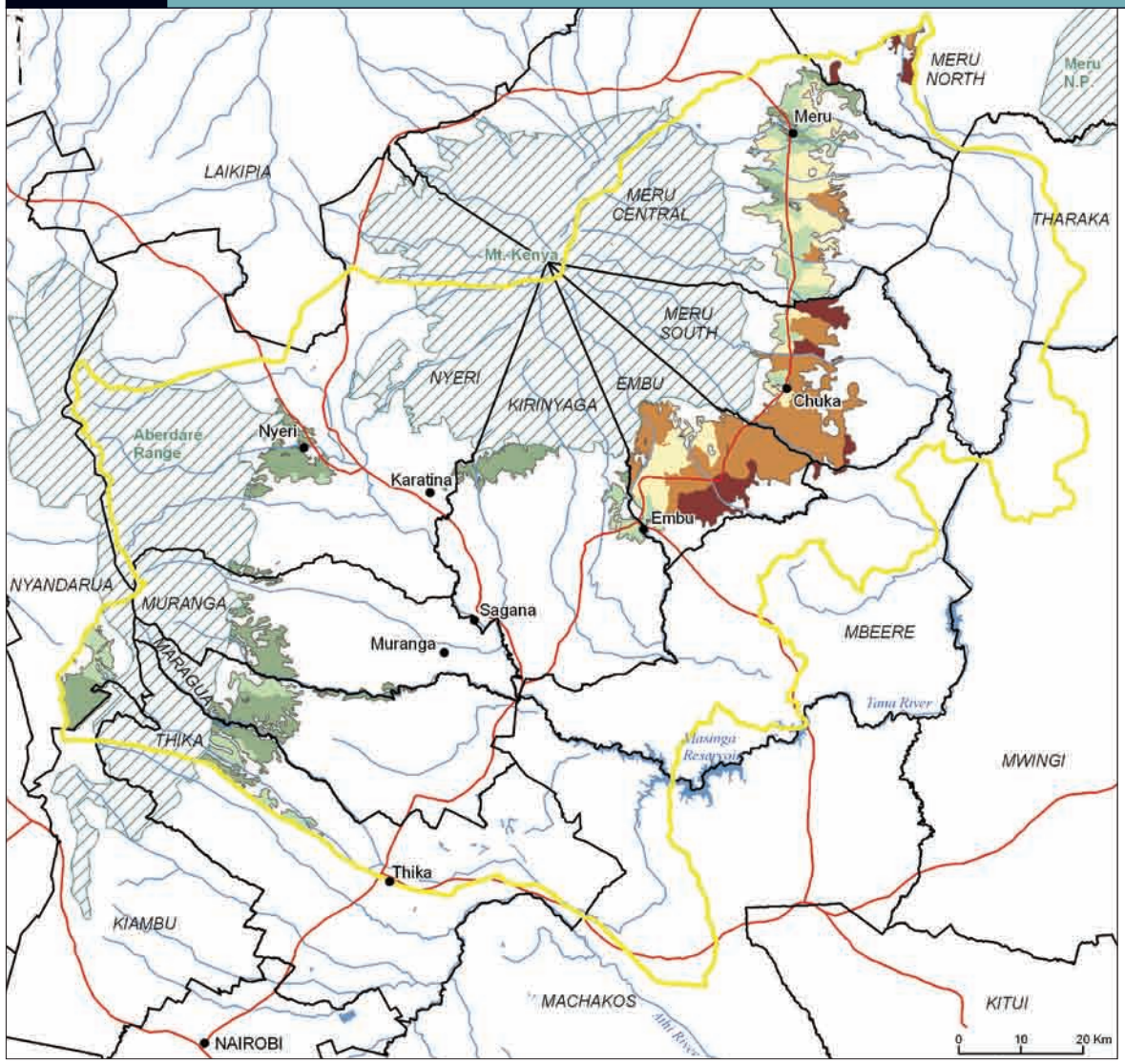
Map 8.18 depicts spatial patterns in the relationship between poverty (poverty rates are shown by Location) and the share of farmland devoted to woodlots. Areas where farmers set aside a relatively large share of cropland (6 percent or more) as woodlots are found across diverse areas

Map 8.17 Upper Tana: Share of Woodlots in Cropland

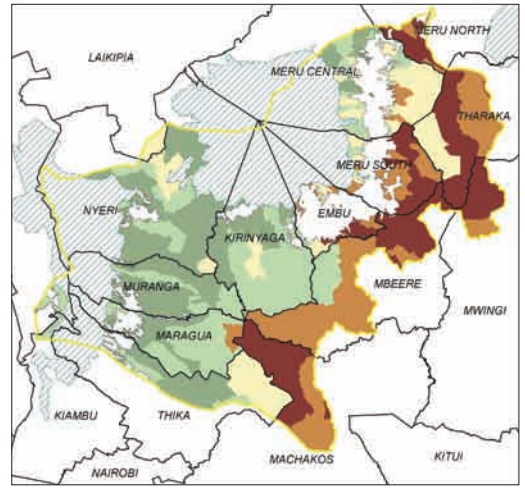


Sources: See Map 7.3.

Map 8.18 Upper Tana: High Share of Woodlots in Cropland and Poverty Rate



Poverty Rate in Areas with Less than 6 Percent Woodlots in Cropland



POVERTY RATE
(percent of population below poverty line)
- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 2.6 and Map 7.3.

of the upper Tana and coincide with low, moderate, and high rates of poverty. In the foothills of the Aberdare Range, areas where a large share of farmland is allocated to woodlots tend to be found in Locations with the lowest poverty rates (dark green-shaded map areas, with poverty rates of less than 35 percent). Locations farther downstream in the Aberdare foothills with poverty rates of 35 to 45 percent (light green areas in the small inset map showing poverty rates for areas with less than 6 percent woodlots) appear less likely to contain cropland with a large share of woodlots.

On the southeastern and eastern slopes of Mount Kenya, areas where a large share of cropland is set aside as woodlots are found in Locations with poverty rates ranging from the very low to the very high. These Locations occur in a large band stretching from the town of Embu to the town of Meru. There is very little apparent difference in the incidence of poverty within this band relative to surrounding areas (see small inset map) where a smaller proportion of farmland is devoted to woodlots.

Thus, the pattern of poverty rates in Map 8.18 indicates a more ambiguous relationship between the share of woodlots in croplands and levels of poverty. It is not clear from the maps alone what factors might account for the differences in poverty rates. For example, the purpose of these woodlots—producing wood for household use, for sale in local markets, or for sale in nearby urban markets—could result in different household incomes and affect overall poverty rates. Such information, coupled with additional analysis, might help identify opportunities for increased wood production on farmlands in poorer communities, perhaps in the lower and drier regions.

High Number of Agricultural Crops and High Share of Woodlots in Cropland

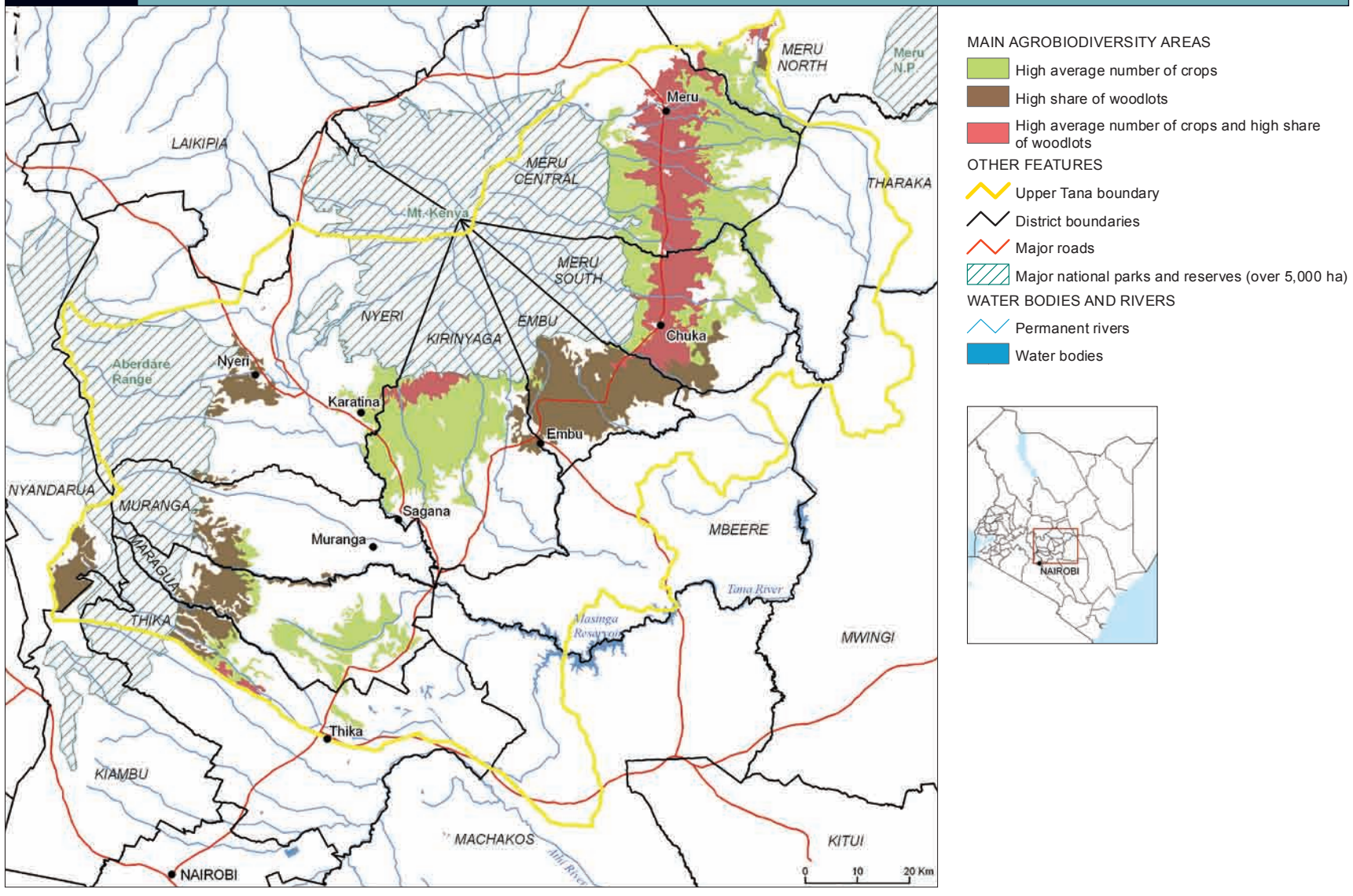
Unlike the map comparing high food cropping and high milk output (Map 8.14), Map 8.19 shows greater spatial overlap between areas with high polycropping and areas with a high share of woodlots in cropland. Nevertheless, the majority of high-supply areas for both indicators do not coincide: high-supply areas of woodlots (shaded in brown) dominate in the Aberdare foothills and in Embu District; areas with a high number of agricultural crops (shaded in green) are predominantly found on the slopes of Mount Kenya in Kirinyaga, Meru South, and Meru Central Districts.

Investigating the different local factors influencing farmers' choices in Maragua, Murunga, and Nyeri—all Districts with high shares of woodlots in cropland—could help to identify opportunities for boosting wood production. For example, wood demand for tea processing (tea-growing areas are in close proximity) or urban energy needs (in nearby Nyeri Town) could be behind these production patterns. Similar factors may explain why farmers in Embu chose to grow a higher share of woodlots than the neighboring communities in Kirinyaga and Embu Districts (with almost identical agroecological conditions). Investigating the underlying reasons for these differences—for example availability of seedlings, training, or perhaps lack of capital—could reveal where introducing new crops or agroforestry practices may improve livelihoods.

The areas of overlap between a high share of woodlots in cropland and high polycropping (shaded in red) stretch along the Chuka-Meru road in Meru South and Meru Central Districts, as well as some more isolated locations in Kirinyaga District. These could become priority areas to increase biodiversity in agroecological landscapes of the upper Tana.

None of the croplands in the drier plains at lower elevations appear as high-supply areas. This may indicate opportunities for future interventions, which may require new crop varieties or tree species that are better adapted and more suitable to the drier conditions.

Map 8.19 Upper Tana: High Average Number of Crops Grown and High Share of Woodlots in Cropland



MAIN AGROBIODIVERSITY AREAS
- High average number of crops
- High share of woodlots
- High average number of crops and high share of woodlots

OTHER FEATURES
- Upper Tana boundary
- District boundaries
- Major roads
- Major national parks and reserves (over 5,000 ha)

WATER BODIES AND RIVERS
- Permanent rivers
- Water bodies

Sources: See Map 5.5 and Map 7.3.

SUMMING UP

Overview

- Within Kenya, the upper Tana represents an important supplier and consumer of ecosystem services. The selected watersheds for the upper Tana fall roughly into three major physiographic regions—mountains, foothills, and plains.
- About 3.1 million people live in the upper Tana area, representing 11.4 percent of Kenya's total population. Smallholder agriculture is the dominant land use and is concentrated in the foothills of the Aberdare Range and Mount Kenya. The government has set aside a significant portion of the land for biodiversity and watershed protection, most of it in the mountainous areas.
- About 1.3 million poor people live in the upper Tana, and the average poverty rate for the region is 43 percent (that is 10 percentage points better than Kenya's rural national average). The area contains a broad cross-section of very poor and less poor communities that have some of Kenya's lowest poverty rates. Most of the poorest communities are located in drier plains downstream of the foothills of the Aberdare Range and Mount Kenya.

Table 8.1 Upper Tana: Demographic and Poverty Characteristics for Areas Outlined by Selected Ecosystem Indicators

INDICATOR	NUMBER OF LOCATIONS OVERLAPPING WITH SELECTED AREAS	SHARE IN THE TOTAL NUMBER OF UPPER TANA LOCATIONS (PERCENT)	NUMBER OF PEOPLE LIVING IN SELECTED AREAS (MILLION)	SHARE IN THE TOTAL NUMBER OF PEOPLE IN UPPER TANA (PERCENT)	NUMBER OF POOR LIVING IN SELECTED AREAS (MILLION)	SHARE IN THE TOTAL NUMBER OF POOR IN UPPER TANA (PERCENT)	AVERAGE POVERTY RATE IN SELECTED AREAS (PERCENT)	LOWEST POVERTY RATE IN SELECTED AREAS (PERCENT)	HIGHEST POVERTY RATE IN SELECTED AREAS (PERCENT)
Water									
High Share of Piped Drinking Water (> 75 percent)	56	25	0.8	25	0.3	22	38	18	64
Small-Scale Irrigation Efforts	107	48	1.5	47	0.7	49	45	21	76
Food									
High Share of Food Crops (> 75 percent)	91	41	1.3	41	0.6	60	46	21	76
High Dairy Output (> 100,000 liters per sq. km per year)	130	59	2.2	69	0.8	52	37	18	71
Wood and Biodiversity									
High Number of Agricultural Crops (> 4)	116	52	1.7	54	0.7	51	41	18	76
High Share of Woodlots in Cropland (> 6 percent)	111	50	1.6	51	0.7	51	42	18	80
Total Upper Tana	**222**	**100**	**3.1**	**100**	**1.3**	**100**	**43**	**18**	**80**

Source: WRI calculation based on Map 8.2, Map 8.3, Map 8.6, Map 8.8, Map 8.11, Map 8.13, Map 8.16, and Map 8.18.

Note: All estimates (rounded to the nearest 100,000; percentages are based on unrounded numbers) of the number of people and the number of poor represent averages for administrative units (Locations) that overlap with the areas delineated by the six indicators. These averages may conceal important poverty linkages at the household level. For example, about 800,000 people (of which 300,000 are poor) live in Locations in which more than 75 percent of the households rely on piped drinking water. This does not automatically mean that 300,000 poor individuals have access to piped drinking water. In fact, it is more likely that the share of poor among the 25 percent of households without piped drinking water is greater than among the 75 percent benefiting from it.

Water, Food, Crop Diversity, and Woodlots

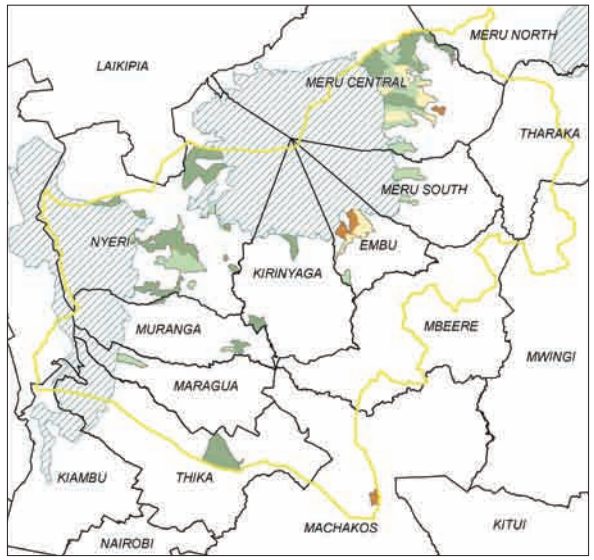
- A large number of communities in the upper Tana rely directly (and exclusively) on ecosystems to filter their drinking water and provide it in sufficient quantity. This is indicated by the great number of communities in which more than 75 percent of households rely on surface water as their primary drinking water source.
- Communities with a high share of piped water (greater than 75 percent of all households) are few in number and are spatially concentrated (including larger towns such as Thika, Nyeri, and Meru).
- There are multiple demands for water in the upper Tana. Most agriculture is rainfed. Water is needed for irrigation, hydropower, drinking water, inter-basin water transfers to Nairobi, and for sustenance of nature (i.e., wetlands and wildlife).
- Large-scale irrigation efforts are concentrated in the plains of two adjacent Districts (lower Kirinyaga and Mbeere) and include Kenya's largest rice irrigation scheme.
- Most small-scale irrigation efforts exist in a ring-like pattern around the base of Mount Kenya, with the largest numbers concentrated in Meru Central Districts. There are fewer small-scale irrigation sites in the Aberdare foothills.
- Most areas with a very high percentage of cropland (more than 75 percent) in food crops are located at lower elevations, including the plains.
- Higher elevations in the foothills—representing the tea- and coffee-growing zone—have generally lower shares of food crops.
- Areas with high milk production are located at higher elevations in the foothills of the Aberdare Range and Mount Kenya.
- Milk production in the drier plains is low.
- Farmers in the foothills of Mount Kenya favor growing a greater number of crops compared to farmers at similar elevations in the Aberdare foothills.
- Areas of high polycropping (where the average number of crops grown is greater than four) extend across most of upper Kirinyaga, Meru South, and Meru Central Districts.
- Most farmers throughout the foothills include wood as one of their crops, as indicated by the share of cropland set aside for woodlots.
- Few croplands at lower elevations in the drier plains contain woodlots.
- The highest share of woodlots in cropped areas are clustered in upper Thika, Maragua, and Muranga Districts. Embu, Meru South, and Meru Central Districts contain croplands with significant woodlot shares as well.

Relationships between Selected Ecosystem Indicators

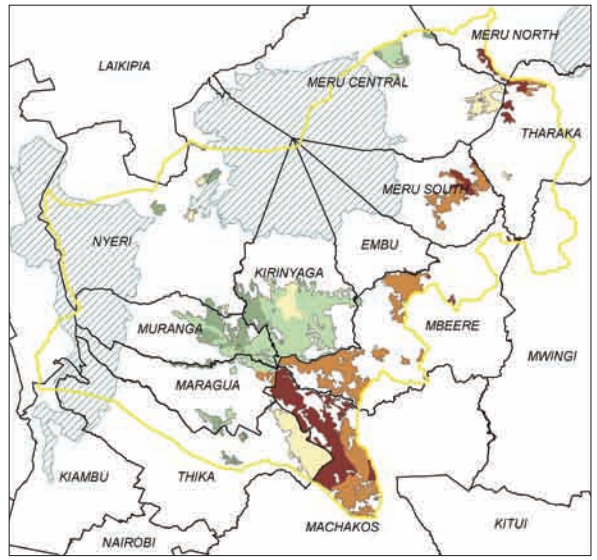
- For large parts of the upper Tana, communities with a high share of piped drinking water and small-scale irrigation efforts do not overlap, except for a relatively large number of communities in Meru South District.
- There is practically no overlap between areas with a high share of food cropping and areas with high milk production. Farmers higher up in the foothills (and to a much larger degree in the Districts east of the Aberdare Range) rely more on nonfood cash crops and high milk outputs for their income than their counterparts further downstream (where production is focused more on food crops and where milk output per unit area is lower).
- Along the Chuka-Meru road in Meru South and Meru Central Districts there is significant overlap between areas with a high average number of agricultural crops and areas with a high share of woodlots in cropland. These areas may thus hold the potential to boost agrobiodiversity.

Map 8.20 Upper Tana: Summary of Poverty Rates in Areas Outlined by Selected Ecosystem Indicators

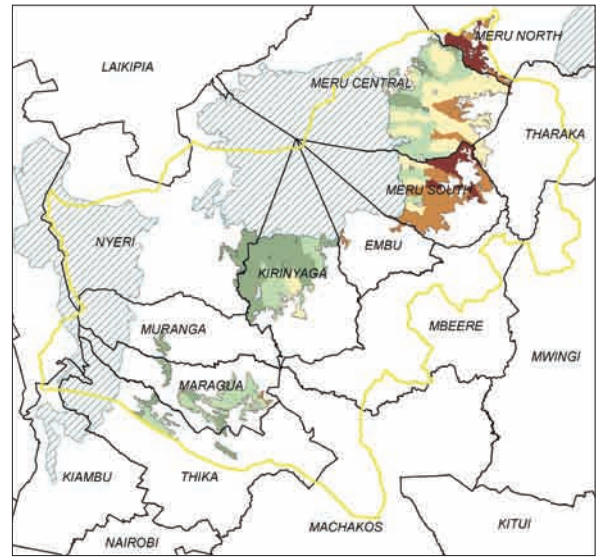
High Share of Piped Drinking Water and Poverty Rate



High Share of Food Crops and Poverty Rate



High Average Number of Crops and Poverty Rate



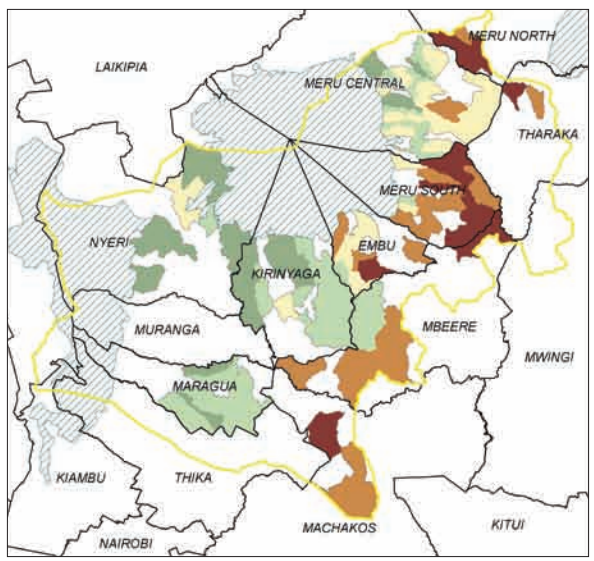
POVERTY RATE
(percent of population below poverty line)

- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35

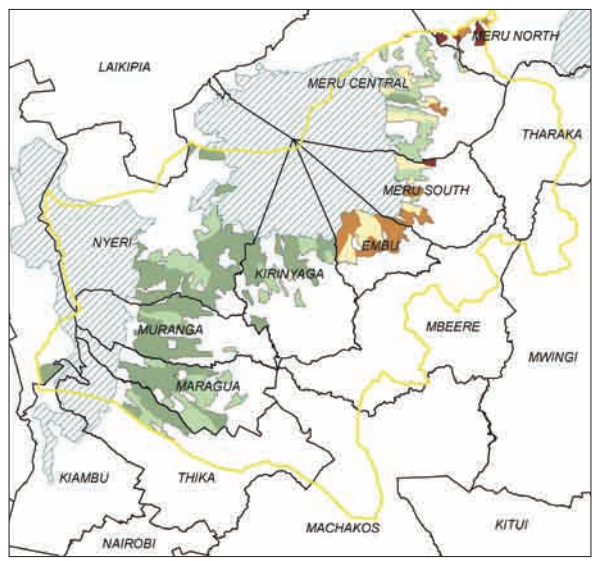
OTHER FEATURES

- Upper Tana boundary
- District boundaries
- Major national parks and reserves (over 5,000 ha)

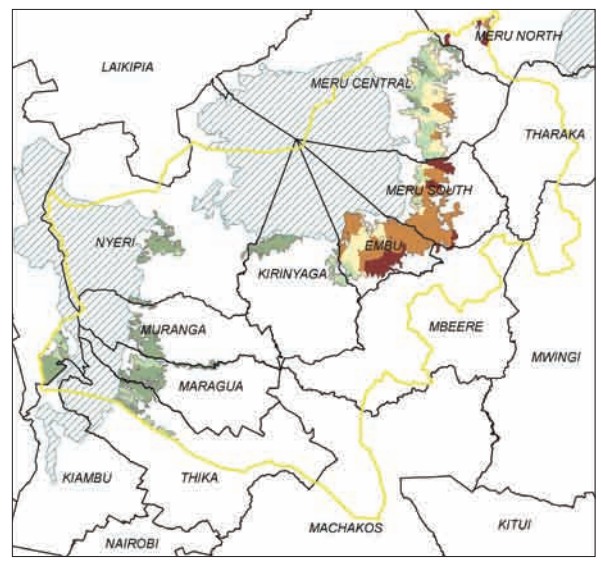
Small-Scale Irrigation Efforts and Poverty Rate



High Milk Production and Poverty Rate



High Share of Woodlots in Cropland and Poverty Rate



Sources: See Map 8.6, Map 8.8, Map 8.11, Map 8.13, Map 8.16, and Map 8.18.

Side-by-Side Comparison of Poverty-Ecosystem Relationships for Selected Indicators

For the purpose of this summary, Map 8.20 brings together the six indicators from the previous maps in this chapter: high share of piped drinking water, presence of small-scale irrigation efforts, high share of food crops in cropland, high milk production, high number of crops grown, and high share of woodlots in cropland. They reflect either investment areas in water infrastructure (to enhance water-related ecosystem services) or represent important supply areas of food-, wood-, and biodiversity-related ecosystem services. Such a side-by-side comparison is useful for describing poverty-ecosystem relationships and identifying locations where key supply areas and poverty patterns coincide. The following bullets show that, for some of the selected indicators, distinct spatial patterns emerge. They also show that for many of the selected indicators, the key supply areas are not automatically associated with lower or higher poverty rates, suggesting determinants that are outside of the selected variables and not necessarily related to geography.

- Communities with a high share of piped drinking water (greater than 75 percent) are concentrated in more affluent areas (Locations with poverty rates below 35 percent). The average poverty rate of administrative areas intersecting with communities that have a high share of piped drinking water is 38 percent, significantly below the average 43 percent for the upper Tana (Table 8.1).
- The poorest areas in the upper Tana have not yet benefited in a major way from piped drinking water.
- Low poverty rates are not automatically associated with higher shares of piped drinking water supplies. This is indicated by communities in the Aberdare foothills that have poverty rate of less than 45 percent but still rely on surface water or have very low shares of piped drinking water supplies in their administrative area (less than 10 percent of the households in the respective areas).
- Small-scale irrigation efforts have reached both poor and more affluent communities as indicated by the great variation of poverty rates for Locations with small-scale irrigation efforts.
- Small-scale irrigation efforts have reached some of the poorest communities, but the number and density in poorer communities is lower than in better-off areas (this does not necessarily mean that they also reached the poorest households in these communities with high average poverty rates).
- A large number of very poor areas in the lower, drier plains have not benefited from small-scale irrigation efforts.
- Areas in the lower, drier plains with a high share of food crops consistently have poverty rates below Kenya's rural national average of 53 percent.
- Locations in Kirinyaga and Muranga Districts do not confirm the simple association between high poverty and high food share—they have a high food share and low poverty rates.
- High milk production in general is more prevalent in communities with lower poverty rates. The average poverty rate for the administrative areas intersecting with high milk production areas is 37 percent (Table 8.1).
- Three areas in the Districts of upper Embu, parts of upper Meru South, and parts of Meru North diverge from this association between high milk output and lower poverty rates—here the poverty rates range between 45 and 65 percent.
- Many areas with high polycropping have low poverty rates and include Locations in Kirinyaga and Meru Central Districts, as well as a few Locations in the Aberdare foothills. However, some areas with high polycropping and moderate and high poverty are found in Meru Central and Meru South District. Therefore, high levels of polycropping are not automatically associated with certain poverty rates.
- The relationship between high share of woodlots in cropland and poverty is ambiguous. In the Aberdare foothills, the highest share of woodlots tend to be in Locations with the lowest poverty rates, and poverty rates are slightly higher in areas with lower woodlot shares. In the Mount Kenya foothills, poverty rates range from very low to very high in areas where a large share of cropland is dedicated to woodlots.

Further Analysis that Would Enhance Understanding of Poverty-Ecosystem Relationships Suggested by the Maps in this Chapter

- Investigate why some communities in Embu and Meru Central Districts with poverty rates between 45 and 65 percent have a high share of piped drinking water.
- In communities that have both small-scale irrigation efforts and high to medium-high poverty rates, find out whether these investments have had a noticeable impact on income, poverty levels, or food security (at more local scale or household level).
- Examine why high-poverty communities in the drier plains have not benefited from small-scale irrigation investments and whether future investments are technically and socially feasible.
- Analyze further the relationship between high share of food crops and poverty in certain areas. Include specific information on the number and type of food crops grown in the analysis and differentiate between high potential and more marginal croplands. Examine whether farmers in one or the other prefer higher-value food crops (e.g., vegetables and fruit) to maize or dryland cereal crops.
- Find the reasons behind the association of higher poverty rates and high milk output in Embu District.
- Determine the obstacles to higher milk output in poorer communities. Examine whether higher milk production is feasible in the poorer communities where obstacles such as availability of fodder and water, milk demand, availability of capital, etc. are present.
- Further examine the relationship between levels of polycropping and poverty. Distinguish between marginal and high-potential croplands and incorporate information on specific crops and reasons for selecting them.
- Search for additional factors that may explain the high share of woodlots in parts of the Mount Kenya foothills (e.g., purpose of wood, labor availability, and returns on investment).
- Examine why farmers in upper Maragua, Murunga, and Nyeri Districts are dedicating such a high share of their cropland to woodlots, and compare it to neighboring communities with similar agronomic conditions.
- Determine the reasons behind the low share of woodlots in poorer, drier lowlands and whether they are linked to agronomic, environmental, economic, and social factors.
- Investigate why a large proportion of communities in Meru South District have benefited from both piped drinking water supplies and small-scale irrigation efforts.
- Find out why farmers in Meru South and Meru Central grow a high number of agricultural crops and dedicate a high share of cropland to woodlots; compare this to neighboring Districts such as Embu.