

Sustainable growth in Machakos

The Overseas Development Institute in collaboration with scientists of the University of Nairobi analysed agricultural development in Machakos District over the period 1930-90. The results of this study show a trend in land use from degradation to enhanced sustainability despite a yearly population increase of more than 3%. The authors focus on management of scarce production factors: land, moisture, soil fertility, fodder and capital.

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The Machakos Reserve is an appalling example of a large area of land which has been subjected to unco-ordinated and practically uncontrolled development by natives. Every phase of misuse of land is vividly and poignantly displayed in this Reserve, the inhabitants of which are rapidly drifting to a state of hopeless and miserable poverty and their land to a parching desert of rocks, stones and sand" (Colin Maher, senior soil conservation officer, 1937).

At that time, the population of the Ukamba Reserve was about 250,000. Extensive livestock raising was combined with shifting cultivation on small hand-cultivated plots of maize and other food crops. Frequent and unpredictable droughts decimated food production and damaged the heavily grazed rangeland. Much natural woodland had been removed and replaced by sparse shrub- and grassland. Farm yields were low and thought to be declining, soil nutrients were depleted, the topsoil was eroding away and livestock numbers were considered to be far in excess of carrying capacity. The official view, as the quotation above made plain, was that the farming system was unsustainable, if not in terminal decline.

The Machakos miracle

In 1990, the population of Machakos District had increased by a factor of six to nearly 1,500,000. Although the district had roughly doubled in size, with the accession of previously uninhabited crown lands, population densities increased from under 80 per km² in the wettest areas in 1932 to nearly 400 per km² in 1989, and from about 50 per km² in the drier areas to nearly 150 per km². The annual rate of population increase peaked at 3.76% in the period 1969-79. Livestock population also increased.

Agricultural output (food and cash crops, horticulture and livestock) increased from less than 0.4 tons per capita in 1932 (converting to maize equivalent at 1957 prices), to nearly 1.2 tons per capita in 1989, and from 10 to 110 tons per km² (Fig 1). Cash crops, particularly coffee, made up much of the increase during the 1970s, and fruit and vegetables production in the 1980s. Cash crops have only very occasionally occupied as much as 15% of cropped areas as there is a need to keep most land

under food crops to avoid purchases at high prices in bad seasons. Nevertheless, because of their higher unit values cash crops are vitally important as income generators. District food sufficiency improved substantially, some households buying, others selling. Living standards also improved through higher cash income.

Soil and water conservation structures were extended, during 1960-90, to almost 100% of the district's arable land, excepting only the flattest and least densely populated areas. By 1990, rangeland was also coming under increasingly careful management. Planting and protecting trees on smallholdings became universal practice. Measured tree densities were found to be highest on the smallest of holdings. The farming system was more, not less sustainable than thirty years before. The changes from a degrading to a conserved landscape are clearly visible in matching photographs taken in 1937 and 1990.

District features

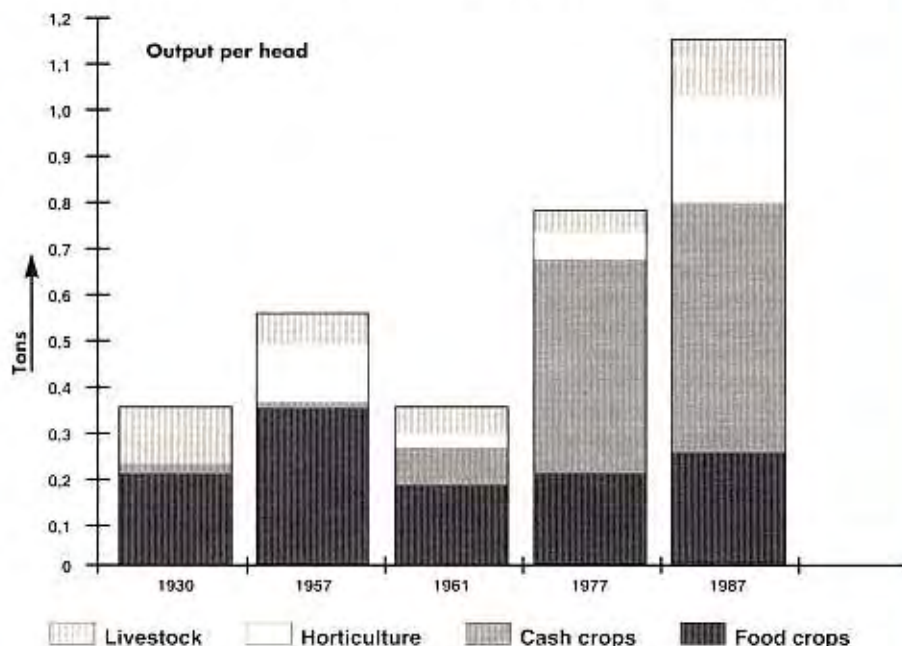
Machakos District contains central hills rising to 1,500 m asl, and dropping to less than 1,000 m in the surrounding plains.

Rainfall reaches over 1,000 mm per year on the hilltops but falls to less than 500 mm on the plains. It is distributed in two short wet seasons, the long rains (March-May) and the short (October-December). Neither may be sufficient for a crop of maize, for droughts are frequent, unpredictable, and often occur in runs of two or more consecutive seasons. Except for small areas of relatively well watered uplands (called "high potential" areas in Kenya), the district is semi-arid. The large scale migration of farming households into "low potential" zones in the 1960s and 1970s gave rise to official fears, both of ecological damage and of increased famine risk. Neither fear has proved justified.

Land-use change

During the century of British occupation of the Akamba country, land has passed from abundance to scarcity. This has led to changes in land use. Figure 2 shows some of these changes between 1948 and 1978, in three representative areas. The first area (Kangundo-Matungulu-Mbiuni) contains a high proportion of land in agro-eco-

Figure 1: Agricultural output per head, 1930-87, converted to maize at constant 1957 prices.



Left: Eroded country near Machakos town in 1937. Irregular patches of bare soil are visible in the middle distance and gullied, treeless slopes in the far distance.



Below: The same area in 1990, with fruit trees on terraces where maize has been harvested in the foreground, terracing on the slopes in the background, and a woodlot on the right.



logical zone 3 (high-potential land). It is most densely populated and longest settled. The second area (Masii) falls entirely in zone 4 (semi-arid upland). Its population density is intermediate and it was settled by households moving out from the hills, largely before 1940. The third (Makueni) represents the drier, warmer and lower zone 4/5 areas settled after 1945.

Figures based on air photo interpretation show the extension of the arable area from 35% to 89% in area 1, from 22% to 50% in area 2, and from 2% to 30% in area 3. The private appropriation of formerly common land (*wetu*) for cultivation took place alongside the abandonment of shifting cultivation in favour of permanent, enclosed fields: a change that was encouraged by the government. It meant a reduction in the grazing areas, the increasing scarcity of which led to their appropriation also. Figure 2 also shows the increase of terracing on arable land. Compulsory terracing schemes were introduced in the 1940s, but they were unpopular because the benefits were unclear. Many terraces fell into disrepair around the time of independence and the figures show that in

1961 the proportions terraced in areas 1 and 2 were essentially the same as those of 1948. Later in the 1960s, however, terracing was renewed voluntarily and farmers began to construct terraces within a few years after opening new land, even in the newly settled areas (like area 3), where average slopes are much less steep. Unterraced arable land had been virtually eliminated in all three areas by 1978, though elsewhere in agro-ecological zone 5 it might still be found. It is significant that most progress was made between 1961 and 1978, when the arable area was itself growing rapidly. Terrace construction continued in the 1980s, and was promoted by the Machakos Integrated Development Programme. By 1990 erosion was considered to be under control on arable land. The problem was, however, only beginning to be solved on grazing land.

Making the most of water

Terracing, originally introduced as a soil conservation measure, also increases soil moisture. In the late 1940s, shallow narrow-based terraces, with the soil thrown downslope (*fanya chini*) were recommended for African smallholders. They

were believed to use labour more efficiently, at a time when labour and tools were scarce, than bench terraces made by throwing the soil upslope (*fanya juu*). However, farmers began to switch over to bench terraces in the 1950s. In 1961, the area conserved by narrow-based terraces had fallen to 19,000 ha (from 35,000 in 1957), partly from poor maintenance and partly due to conversion to bench terraces. By 1990, less than 5% of all terraces were narrow-based (Gichuki 1991).

Bench terraces were desired initially for vegetables, which became profitable in the early 1950s. When African farmers were permitted to grow coffee (from 1954), they were subjected to stringent rules which included the construction of bench terraces. Now they are used for all crops. Bench terraces waste no land, as the bank can be used for fodder crops and the ditch can be planted with fruit trees. They are better at water conservation because the ditch at the rear provides water to the terraces, not, as on narrow-based terraces, to the bank. Maintenance costs are lower. The population growth and associated diminution in holding size increased the incentive to invest in the land.

A major reason given by farmers for constructing terraces was observed yield improvements. Labour, which used to be organised through government compulsion, was later on provided through community self-help groups (*mwethya*), which could work on private farms in turn. It is now often hired. Terrace building calls for substantial labour mobilisation for short periods and may therefore be beyond the resources of the household, unassisted. Much, if not most, labour is provided by women, as men are more involved in off-farm work.

Water scarcity, whether for domestic, livestock or crop use, results from the low and variable rainfall, high runoff losses, momentary stream flow, low groundwater yield, low moisture holding capacity in soils and high rates of evaporation. Most critical is water availability for arable farming. Various strategies are available for maximising the efficiency of water use. Smallholders in Machakos learn from their neighbours, extension officers and their own experiments. For example, on the 2 ha farm of Mr Musyoki, in agro-ecological zone 4, the following measures may be observed: cut-off drain with bananas planted in pits, bench terraces, diversion of

roadside runoff for crop use, conservation tillage, mulching, weed control and manuring, mixed cropping with fruit trees, beans and maize, live fencing used as a wind-break, supplemental irrigation from pond storage for vegetables and the use of grafting to diversify and improve fruit yields (Fig 3). Mr. Musyoki used to be a waiter in Nairobi. He started farming on degraded land in 1970.

Recycling soil nutrients

Soils of Machakos are naturally deficient in phosphorus. Repeated cultivation without fertilisation reduces nitrogen, carbon and exchangeable cations to low levels (Table 2). Even long fallowing under grazing fails to restore soil nutrients to the levels found on uncultivated land. Fertility management is therefore critically important for the sustainability of arable farming.

There are four main soil improvement options: inorganic fertilisers, *boma* (farm-yard) manure, alternative organic sources (compost, mulches, green manure), and use of nitrogen fixing legumes as intercrops, rotations or farm trees (Mortimore and Wellard 1991). Except for the use of nitrogen fertilisers on the profitable coffee crop, manure has been the mainstay of soil improvement efforts since the 1930s and 1940s, when it acquired a commercial value and the Department of Agriculture started promoting it. Adoption is now nearly complete, in terms of the numbers of farmers using it. However, supply constraints (number of livestock or working capital available) restrict its application on most farms to levels well below those desired for optimal nutrient supply.

Composting offers an addition to manure and by combining manure with plant materials, it can double the supply of organic material available. It was first promoted by the Department of Agriculture in the 1930s, but did not become popular then. Recently, it has been taken up again by NGOs working in the district. In a scheme run by the Kenya Institute of Organic Farming, farmers' groups combine their labour for compost making using, amongst other materials, the invasive weed *Lantana camara*. The system represents a further step in labour intensification.

Manure and compost improve nitrogen and phosphorus levels, soil structure and moisture retention. Leguminous crops are already important. Inorganic fertilisers usually cannot be justified economically, except for high value crops such as coffee (138 kg/ha in 1988). Although use on food and horticultural crops increased in the 1980s, averages are still very low (1.6 kg/ha in 1988). Inorganic fertilisers have always been recognised as a second best to manure.

It is not known what quantities of manure are applied in the district. However, since the 1930s, the output of food and cash

crops and horticulture has increased by a factor of 11 per hectare, while the area of arable land has grown by a factor of 6 (Rostom and Mortimore 1991). The (inadequate) data indicate that crop yields did not fall, and probably rose, both for maize and for the market crops (Mbogoh 1991). Farmers combine a research-derived drought tolerant maize variety with local varieties.

Feeding livestock

Livestock data are weak and contradictory. However, the number of stock units (1 unit = 1 cow or 5 sheep/goats) seem to have risen from just over 200,000 in the 1940s, a time of frequent droughts and high mortality, to at least 334,000 and possibly as many as 588,000 in the 1980s (Ackello-Ogutu 1991). Allowing for the change in area, overall densities fell from 2.4 ha/unit in the 1940s to 4.4 in the 1980s (if the lower figure is accepted) or remained virtually the same at 2.5 (if the higher is accepted). In high population density areas the need for more productive feeding systems was unavoidable as, owing to subdivision on inheritance, the average size of Akamba holdings is constantly diminishing. The transformation of livestock feeding systems, which is yet incomplete, consists of three linked steps (Mortimore and Wellard 1991).

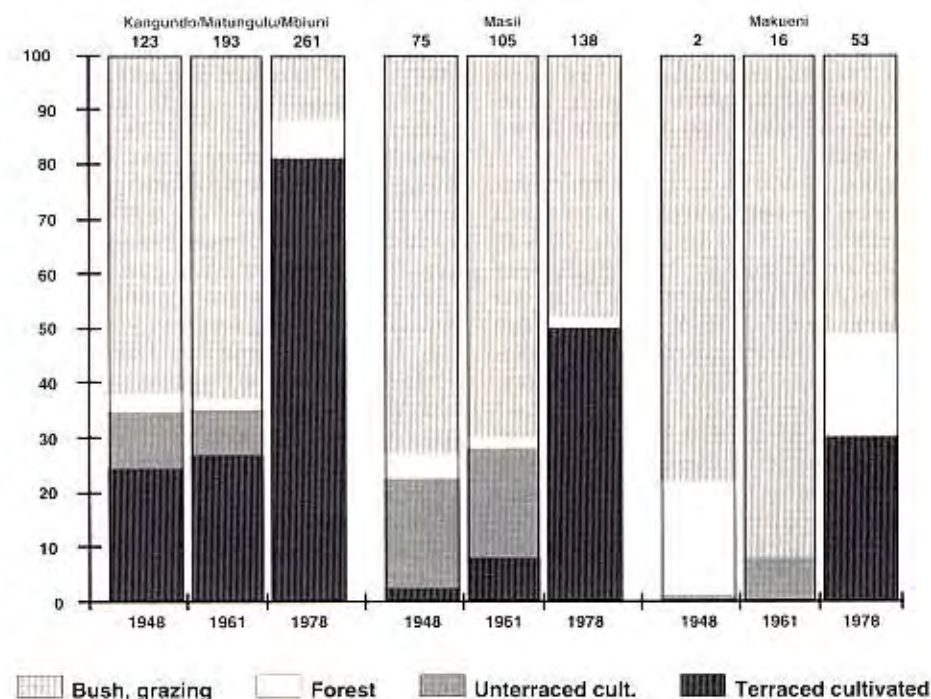
First the private appropriation of almost all common land forced a matching of stock holdings with carrying capacity at the level of the individual farm. Otherwise degradation threatened the long-term viability of the holding, a critical considera-

tion in planning for one's heirs. In agro-ecological zone 5 no evidence was found of grazing-induced degradation of the natural vegetation. Rather, the proscription of fire as a management tool has allowed the increase of woody species on rangeland where grazing has been introduced mainly during the last three decades. On private land with a long history of intensive grazing in zone 4, farmers employ destocking, grass planting, control of unwanted species and tree protection to manage the ecosystem sustainably. The stabilisation of formerly mobile grazing circuits within the bounds of private holdings increased the use of crop residues as fodder. Maize stalks and bean haulms are used universally for this purpose.

Second, fodder grasses and trees are now grown on terrace banks and farm-lands respectively. Fodder grasses were promoted by the government as long ago as the 1930s. In the early 1950s it was shown in a government experiment, at the "Makaveti square mile", that such grasses grew well even on degraded land, and that they could support much higher cattle densities than had been thought possible, namely up to 0.4 to 1.6 ha per livestock unit (Ackello-Ogutu 1991). Today, the grasses *Pennisetum purpureum* (Napier grass) and *Panicum makarikariensis* play an important role in integrating the crop and livestock sectors and intensifying the farming system.

Third, stall feeding of livestock is practised now by 59% of cattle, 53% of sheep and 50% of goat owners, respectively, for part or all of the year. This method permits

Figure 2: Landuse in three areas, 1948, 1961 and 1978, from air photo interpretation



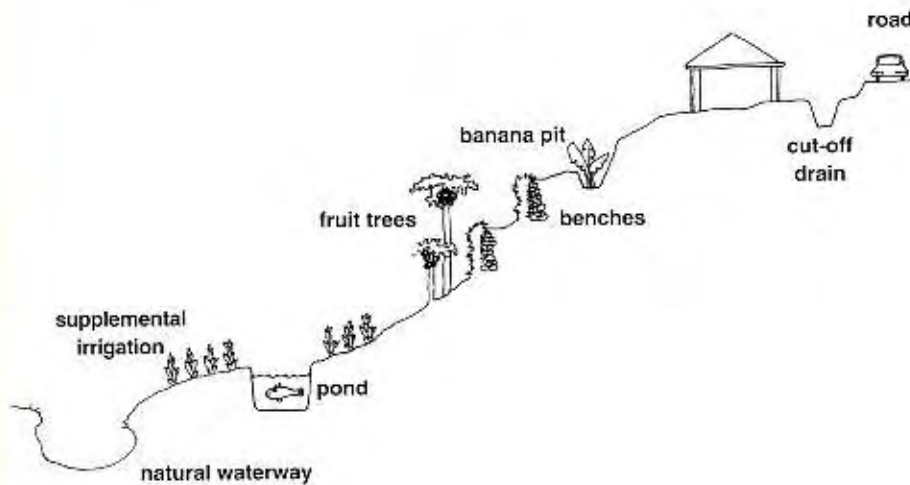


Figure 3: Mr. Musyoki's farm demonstrates ways of conserving water and increasing crop output which are now common in Machakos.

more efficient use of residues and fodder crops and more systematic use of manure. It disposes of the problem of where to put livestock during the growing season, on crowded arable holdings, and protects terraces from damage by grazing animals.

Ecology and population density influenced the adoption of both fodder production and stall feeding. In Kangundo (area 1 in Fig 2, and in agro-ecological zone 3), almost all farmers are now reported to plant fodder, and stall feeding is the most common feeding system. In Masii (area 2, and in zone 4), only a few plant fodder or practise stall feeding. In Makueni (area 3 and in zone 4/5), while some plant Napier or Rhodes grass, stall feeding was tried earlier but abandoned. In Ngwata, in zone 5, no farmers do either (Mortimore and Wellard 1991).

Finding capital

Even when land was abundant, capital was necessary for its development. As land scarcity increased, capital supply became critical in the adoption of technologies of intensification and conservation: the construction of terraces and other soil and water conservation structures and enclosures, the purchase of fertilisers, the acquisition of ploughs or fixed farm capital, entry to coffee production, the purchase of improved livestock and access to markets.

The experience of Machakos supports the Boserup hypothesis that increasing population density leads to intensification through changing labour to land ratios. However, labour intensification cannot be isolated analytically from capitalisation. Labour for land improvement and tree planting was hired, as well as supplied from family and communal sources. Not only does capital substitute for labour, but in many technologies it supplements it. For

example: terrace construction requires tools, effective manuring and composting require ox-carts and water drums, grade livestock require frequent dipping, coffee and vegetable crops need purchased inputs.

The Community Development Department (under the leadership of John Malinda) adapted the traditional mwethya work party, used to create new farms or houses, to the needs of soil conservation in the 1950s. The mwethya groups appointed their own leaders and worked on their members' farms in turn. Leaders and musicians were often women, since so many men were away working. Nowadays they are used to raise both capital and labour, for community as well as private projects - schools, bridges, businesses as well as terraces - while NGOs

are using them to identify, plan and carry out projects. The mwethya groups, therefore, have made a major contribution to the capitalisation of the economic landscape (Mbula Bahemuka and Tiffen 1991).

However, capital was also derived from farm profits (sales of livestock and crops) and savings from waged work or non-farm enterprises. We were unable to measure the respective contributions of labour and cash investments, but there is no doubt the latter were substantial.

Conclusion

Change, intensification and conservation were driven by population growth, increasing land scarcity, investment, and new information and technologies. In livestock management, the evolution from extensive grazing in the 1930s, through increasingly labour-intensive methods, to the growing popularity of stall feeding in the 1990s, illustrates the general trend towards intensification. In the process, the Akamba have come to value livestock not only as a savings reserve, which can be utilised in emergencies or to provide investment capital, but also as sources of farm energy, manure, and regular income from milk and meat sales.

It is a major conclusion of this study that the market facilitated and promoted change. In the 1930s, better-off farmers invested in ploughs to produce maize for the market. Coffee generated investment income in the high potential areas from the 1960s. Canning factories and traders were amongst those providing credit, incentives and information for fruit and vegetable production. However, it is questionable whether reinvestment of agricultural profits could alone provide all the capital needed to transform the farming system. To a certain extent, capital can and did take the form of direct labour investments, by family labour or groups. The external labour

Table 1: Maximising the efficiency of water use

<i>Requirement</i>	<i>Measures</i>
Water management	
Controlling runoff, water storage, optimal water allocation	- water harvesting (e.g., terraces, cut-offs, pits for trees) - supplemental irrigation - re-use of water
Soil management	
Improving soil moisture and nutrient holding capacity	- controlling capping and sealing - improving structure - conservation tillage - fertilisation
Crop management	
Optimising crop use of water	- selecting drought tolerant, drought escaping or high value crop varieties - adapting cropping system (e.g., inter- or relay cropping, agroforestry) - optimizing plant populations - weed control - crop diversification

Right: The Kalama Hills in the background are covered with erosion scars, and a great deal of exposed rock or soil is visible in the stream beds (1937).

Below: In 1990 a great deal of the arable land has been terraced, and most of the grazing area, now privately managed, is in no worse condition than 1937, despite the greater scarcity of this resource.

market was also an important source of both capital and information. Many Akamba joined the army and police, travelled widely and brought back savings and new ideas. Education was seen as giving access to employment outside the district and outside the farming sector, the value of which in years of crop failure and livestock mortality was apparent. Households used income diversification both to secure themselves against risk, and to build up savings for investment in the farm (as illustrated by Mr. Musyoki's farm). Other investments, of work and cash, were in community infrastructure, such as feeder roads and schools.

A typical investment cycle was to seek market participation, either for labour or for farm products, to generate income. This income was used to educate children. Some children, (predominantly males, but increasingly, females also) on attaining maturity, took jobs inside or outside the district, sending part of their earnings to support the family and/or to finance investments. Productive investments increased farm incomes and the value of the land. The holding was subdivided on the owner's death amongst heirs, into smaller but by then more fertile parts, and the cycle was repeated.

The most important implication of this development is that technological change was functionally linked with income diversification and increased market participation: the sustainability of the farming system cannot be considered in isolation from the household economy as a whole. The relatively small areas of high value crops, typified by Mr. Musyoki's vegetable plot, help to generate the incomes which enable farmers to improve their houses, and to purchase more goods and services, thus creating more off-farm employment locally. By 1981-82 a national survey showed that in Machakos only half the rural income was generated by the farm, the rest by other activities. In some of the more densely populated districts of Kenya, with higher average incomes than Machakos, the proportion of non-farm income is even higher.

What future for Machakos?

Although typical family size is now being reduced in Machakos, population will inevitably continue to increase, given the age structure. There is still scope for agricultural intensification in parts of the district, which could be facilitated by improving market



Photo: Kenya National Archives



Photo: Michael Mortimore

access. Output per hectare in a given agro-ecological zone is far higher on small farms than on large, as the small farms use more working capital per hectare (Tiffen 1992). At the moment, the insufficient road network is decaying, limiting marketing opportunities for milk and vegetables and reducing farm-gate prices on livestock and other products. People are energetically seeking new non-farm income sources. Craft industries, such as the manufacture of the well-known Machakos sisal basket, woven by women, or the wooden carvings made by men, are expanding. Village leaders we interviewed in a very densely populated area said they needed rural electrification, to enable them to process more agricultural products, to establish more workshops catering for local needs and to generate more employment. This is happening in the few places in Machakos that have good roads and an electricity supply.

Machakos will change again in the future. Given policy support, it will become more urbanised and industrial. However, there is no reason to think that this will undermine the sustainability of its agricultural base. ■

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