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Agricultural production in Kikwawila village, southeastern Tanzania

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Summary

Food production, land utilisation and agricultural structures were surveyed at Kikwawila village, north of Ifakara (Kilombero District, Morogoro Region) in 1984. This study was part of a more comprehensive, longitudinal programme to investigate the health status of a rural community, aiming in particular at the interrelations between nutrition, parasitic infections, immunity and the environment. Out of 340 households, 100 were interviewed and their subsistence farming activities recorded. The soil was found to be of great variability, being fertile where it was of alluvial origin but of reduced potential where it was non-alluvial. In all, 70 plant species were registered as being cultivated, with rice, maize, cassava and beans providing the main staple food. Apart from a few exceptions, the fields were cultivated without any mechanization. The seasonal distribution of agricultural work is described, but no detailed workload analysis of the villagers with regard to age and sex has been performed. At the foot of the mountains, where artificial irrigation has been introduced, dry season cropping was practised in addition to the prevailing wet season farming, which rendered the cultivation of marketable crops (mainly tomatoes) possible.

The farmers were found to be imaginative and capable of adapting to various conditions, irrespective of their tribal origins. Alternatively, the quality of the soil and the unreliable availability of water set limits to the potential of food production in the area. Although land is still available, it is becoming more scarce as the human population increases. The further impoverishment of the land represents an imminent danger. Therefore, top priority ought to be given to soil conservation, followed by intercropping and/or crop rotation, seed production and crop protection against game and pests. Means of implement-

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ing such measures are discussed. It is suggested that Community Agricultural Workers be installed, elected by the villagers and trained to establish the link between the existing agricultural extension service and the farmers' communities.

Key words: food production; subsistence farming; agriculture; soil; Tanzania.

Introduction

This study, undertaken at Kikwawila (Kilombero District, Morogoro Region), was initiated after investigations on the community health status (Tanner et al., 1987a, b) and food consumption (Lukmanji and Tanner, 1985; Tanner and Lukmanji, 1987) had indicated nutritional problems and impaired food availability within the local community. Dietary surveys to assess food pattern and intake, undertaken in 1983, revealed that the diets of all age groups of the population were highly deficient in energy and protein in the lean season (February) and still deficient in energy in the post-harvest season (August). This led to the conclusion that food production was inadequate and, hence, to the necessity of conducting an agricultural survey in the same area.

This paper is based on the comprehensive report on an agricultural survey performed in 1984 (Zehnder et al., 1986), which assessed the existing agro-economic structures as well as the actual field management and crop production conditions, and proposed possible improvements to the existing agricultural situation. Such improvements should contribute substantially to raising the community health status and, more generally, to raising the standard of living.

Study area and Methods

The study area has been described elsewhere (Tanner et al., 1987b). This investigation has been carried out in all four sectors of Kikwawila village, i.e. in Kikwawila, Kapolo, Lower and Upper Kilama.

One hundred households out of a total of 340 were selected for the survey. These included the 39 households randomly selected for the previous food consumption food survey at Kikwawila and Kapolo (Lukmanji and Tanner, 1985; Tanner and Lukmanji, 1987), 31 additional households in the same village sectors and 40 more households in Kilama, all picked randomly. The locations of the chosen households are shown in Fig. 1. The 1982 census (Tanner et al., 1987b) served as a basis for a stratified sampling according to household size (stratum I ≤ 3 members, stratum II >3 members). Interview forms were designed to obtain information on demography, annual, and perennial crops. The questions focused on soil and crop management, crop selection, animal husbandry, pests and other problems.

All the selected households were asked to participate and no head of household refused to enter the study. All households were visited by one of us (A.Z.) and a trained indigenous staff member, at least four times during the year of the investigation. As a rule, the head of household and a woman in each household were interviewed. Women were always interviewed since they did most of the farming work. In addition, observations were made at field and household level, to obtain a quali-

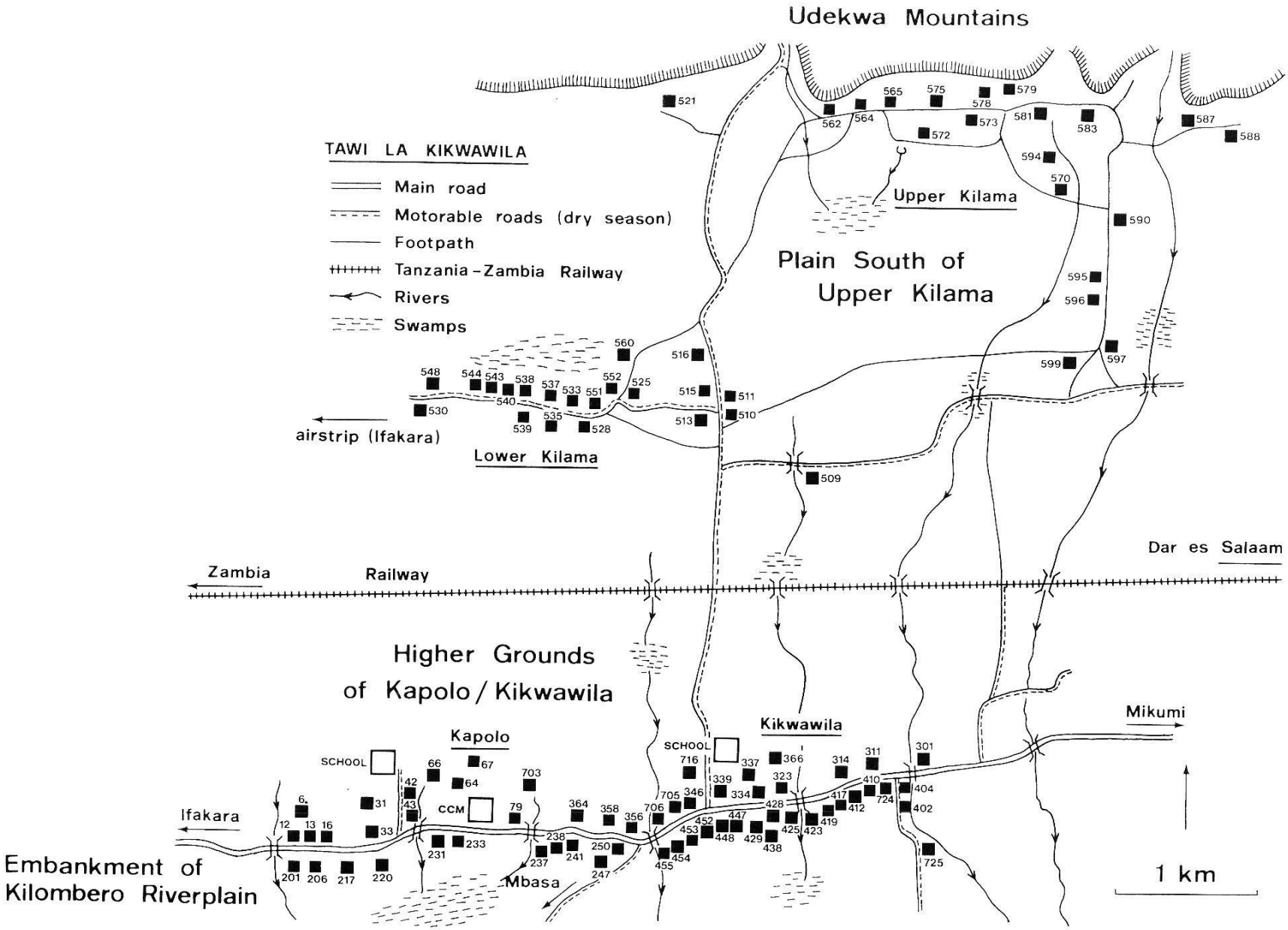

Fig. 1. Location of selected households observed and interviewed during the agricultural survey in Kikwawila village in 1984 (from Zehnder et al., 1986).

tative overview of different agricultural problems and information on house and store construction and condition, and on the involvement of the population in food trading and other cash-generating activities. Occasional observations by other project staff working in the same area were also recorded.

Soil surveys were made during the dry season (June to November) in all village sectors. Samples were taken using a hand driven soil-auger (length 1 m) and different soil layers were macroscopically described. The criteria of the description of the soil layers were a) the depth of the layer, b) an estimation of the content of organic matter, c) colour, d) texture (sand, loam, clay) and e) skeleton-content (e.g. gravel, stones), About 140 soil samples from different fields of the selected 100 households were examined. For more thorough analysis, selected samples were sent to a specialized laboratory (Laboratory Balzer, Amönau, FRG).

Results

Soils

A great variety of soil types of alluvial and non-alluvial origin, were found within the 50 km^2 area of Kikwawila village, the main 9 of which are listed and mapped in Fig. 2. There were very few fields in Kikwawila village with only one type of soil, even on surfaces as small as 1–3 acres.

Alluvial soils were found predominantly at the foot of the escarpment near Kilombero tributaries, where these entered the riverplain, often forming alluvial fans (Jätzold and Baum, 1968; Mauderli, 1981). Alluvial soils were free from floods during rainy season and had a high mineral content as well as a high percentage of organic matter (FAO, 1961). These soils often showed a high water infiltration rate and at the same time a favourable soil-moisture availability to the plants (Bonarius, 1975). The vegetation there was dense, indicating the high fertility of these soils.

Non-alluvial soils were more predominant in the study area than alluvial soils. They consisted of marginal sand flats (Jätzold and Baum, 1968) of former *Brachystegia* woodland or of flood savanna of the Kilombero river. They showed a very low content or organic matter (Table 1).

Crops

More than 70 types of crops, a wide variety, were recorded in Kikwawila village in 1984 (Zehnder et al., 1986). Staple food plants are listed in Table 2 and their distribution across the area is shown in Fig. 3. Rice, maize and cassava were predominant. Rice, the most important food of the people of the Kilombero valley (Lukmanji and Tanner, 1985; Tanner and Lukmanji, 1987), was usually sown during the rainy season when some 80% of the rice fields were semi-permanently flooded. In the remaining fifth of the fields upland rice was sown straight out onto the fields without irrigation. A single farmer was found to practise transplanting rice from a seedbed to a field in the rainy season. Direct sowing gave most uncertain yields since flooding of the fields could not be foreseen and no water control was possible in the fields.

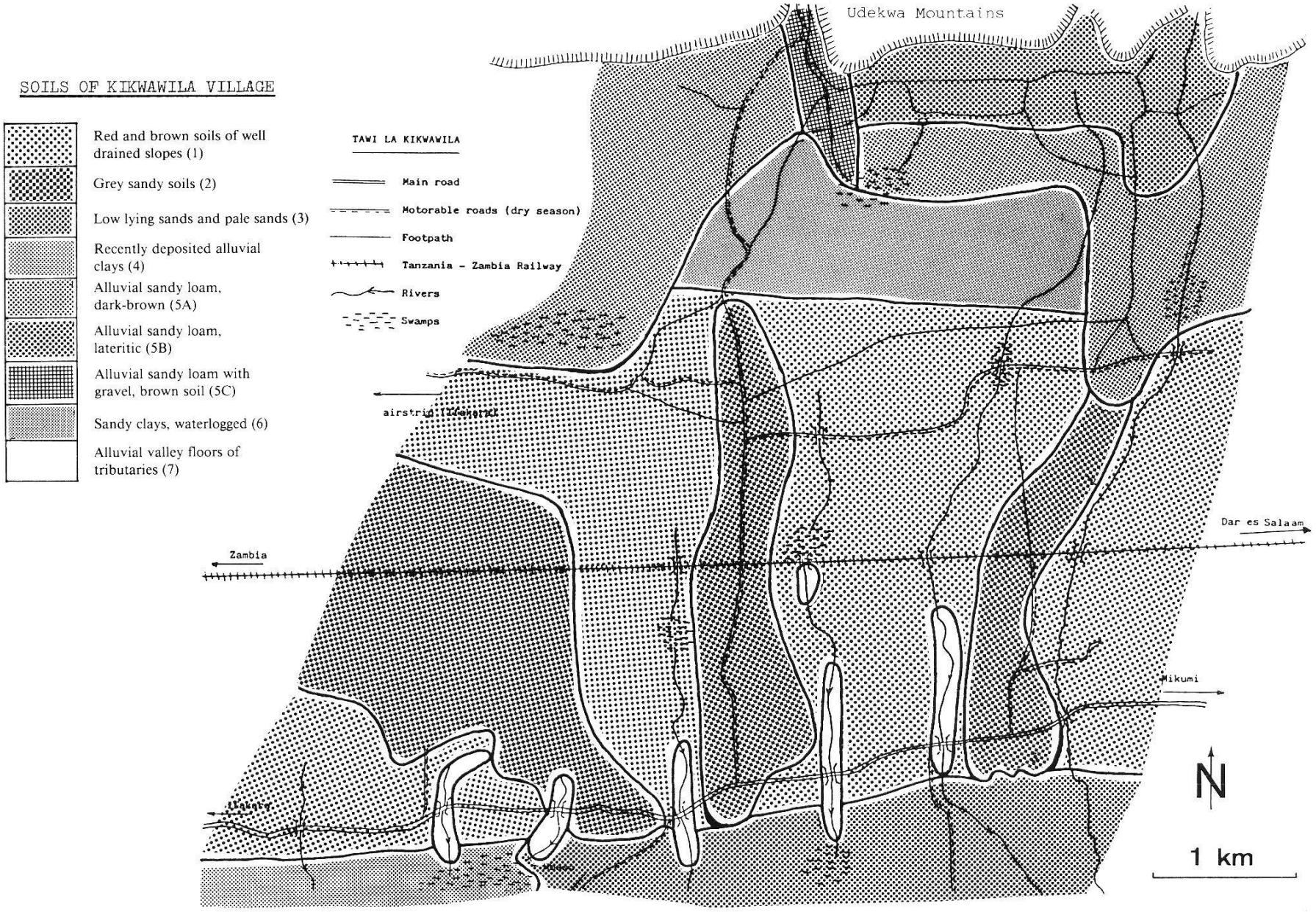

Fig. 2. The major soil types of Kikwawila village (from Zehnder et al., 1986).

Table 1. Analysis of soil samples from different sites in Kikwawila village (from Zehnder et al., 1986)

Sample No.		1	2	3	4	5	6
House No.[a]		78	78	301	301	12	12
Depth of sample (cm)		0–40	50–80	0–40	50–80	0–40	50–80
Organic matter (%)		1.1	0.6	6.2	1.8	1.2	0.5
pH	(H_2O)	6.5	6.6	7.1	7.1	6.6	6.6
	(0,1 n KCL)	5.6	5.5	6.3	5.8	5.7	5.5
Ca*	(HCl/H_2SO_4)	40	30	320	120	40	30
P_2O_5*	– (Na-acetate)	1.2	1.1	4	1.9	1.4	1.5
	– (DL)	4	3	13	3	2	2
	– (Citrate)	7	5	23	9	6	5
K_2O*	– (Na-acetate)	2	4	24	14	3	3
	– (DL)	7	12	24	14	5	5
Mg*	(DL)	15	23	53	34	10	10
Cu*	(HCl/H_2SO_4)	0.23	0.23	0.19	0.30	0.20	0.22
Fe*	(HCl/H_2SO_4)	3	3	4	10	6	5
Mn*	(HCl/H_2SO_4)	5	3	10	4	3	2
Zn*	(HCl/H_2SO_4)	0.1	0.1	0.8	0.2	0.1	0.1

* mg/100 g air-dried soil, DL = double lactate

[a] indicates site where the sample was taken, for house numbers and location see Fig. 1

Maize was often intercropped with cassava and planted either on sandy ridges (Kikwawila, Kapolo, Lower Kilama) or in the fertile soils of Upper Kilama. There, dry season cropping was frequent and successful due to artificial irrigation. The maize varieties were often very old breeds. New varieties were difficult to obtain from National authorities and those offered did not seem to be well adapted to the conditions of the area. The population considered cassava a «hunger crop». It was relied on mainly when rice and maize were scarce. It was planted in fields, preferably of sandy soil, and in gardens next to the houses.

Production sites

The areal distribution of the major production sites for the rainy and the dry season are shown in Figs. 4 and 5, respectively. The comparison of the two figures demonstrates a striking difference between wet season and dry season cropping and illustrates the limited use of comparatively large surfaces when no water is available.

Table 2. Major crops in Kikwawila village (from Zehnder et al., 1986, modified)

	English name	Scientific name	Kiswahili name
Rice	paddy/swamp	*Oriza sativa L.*	mpunga bondeni
	upland		mpunga mlimani
	black		sigara
	red/brown		faya rangi
	white		indica
Maize		*Zea mays L.*	mahindi
Cassava		*Manihot esculenta* Crantz	muhogo
	green stem		yuda
	red stem		kigoma
Beans	kidney	*Phaseolus vulgaris* L.	maharagwe
	green gram	*P. aureus* Roxb.	choroko
	lima	*P. lunatus* L.	ngungutu
	pigeon pea	*Cajanus cajan* Huth	kunde miti/mbaazi
	cowpea	*Vigna unguiculata* Walp.	kunde hati/ndambahi
	dolichos	*Dolichos lablab* L.	fiwi
	bambara groundnut	*Voandzeia subterranea* Thou.	njugu mawe
Tomatoes ..		*Lycopersicon esculentum* Mill.	nyanya
Sorghum ...	tall stem	*Sorghum bicolor* Moench	mtama
	small stem	*S. caffrorum* Beauv.	serena
Millet	true	*Panicum miliaceum* L.	mkia wa nyumbu/ kimbangala
	finger	*Eleusine coracan* Gaertn.	ulezi
	bulrush	*Pennisetum glaucum* L.	uwele
Sugarcane ..		*Saccharum officinarum* L.	miwa
Oil crops ...	sesame	*Sesamum indicum* L.	ufuta
	sunflower	*Helianthus annuus* L.	alizeti
	cashew nut	*Anacardium occidentale* L.	korosho
	groundnut	*Arachis hypogaea* L.	karanga
Root crops	sweet potato	*Ipomea batatas* Poir.	kiazi kitamu
Vegetables	taro	*Colocasia esculenta* Schott.	libehe
	amaranth	*Amaranthus* spp. L.	mchicha
	cassava (leaves)	*Manihot esculenta* Crantz	kisamvu mpira
	«spinach»	*Sclerochtion obtusisepalus* L.	mlenda
	lady finger	*Hibiscus esculentus* L.	bamia
	cucumber	*Cucumis sativus* L.	matango
	eggplant	*Solanum melongena* L.	biringanya
Nuts and fruits	coconut	*Cocos nucifera* L.	nazi
	banana	*Musa* spp. L.	ndizi
	mango	*Mangifera indica* L.	embe
	orange	*Citrus sinensis* L.	mchungwa
	pawpaw	*Carica papaya* L.	papai
	pineapple	*Ananas comosus* Merr.	nananasi

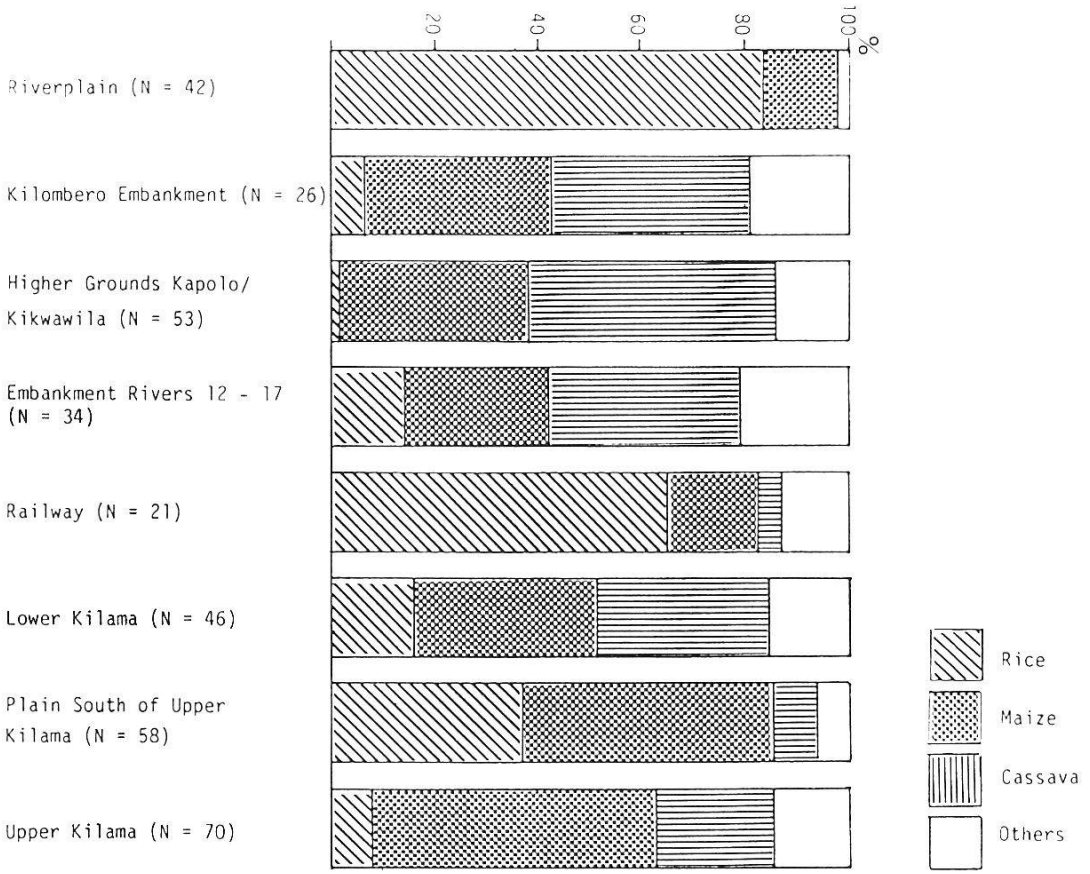

Fig. 3. Proportions of rice, maize and cassava from totally cultivated areas in different locations of Kikwawila village. For locations see maps 1 and 2 (from Zehnder et al., 1986).

Typical rice areas were the Kilombero river plain, fields along the railway, and the plain south of Upper Kilama. 89% of the 100 households surveyed planted rice, covering a total of 204 acres with a mean of 1.8 acres/field. Maize alone was predominantly cultivated at Upper Kilama and in the plain to the south, and maize intercropped with cassava was found mainly at Lower Kilama, Kapolo and Kikwawila. 93% of the households surveyed planted maize, covering 286 acres or 54.9% of the total cultivated land in the rainy and in the dry season. Cassava was planted mainly in the fields near Kikwawila and Kapolo. Other cassava plantations were found on the Kilombero embankment, the embakments of the tributaries and at Lower Kilama. 94% of the households surveyed had cassava fields. Beans were often cultivated as intercropping partners to maize and cassava. 42% of the surveyed households had some beans, most frequently pigeon-peas and cowpeas (cf. Table 2). The various types of millet were found mostly near Kilama and only at Upper Kilama were tomatoes raised by artificial irrigation. Not more than 29% of the households surveyed cultivated perennial crops, but all households kept a few perennials such as bananas, cashew or citrus around their habitations. Perennial fields contained either bananas (Kilama) or cashew (Kikwawila and Kapolo).

Neither Fig. 4 nor Fig. 5 show the garden crops cultivated in the vicinity of

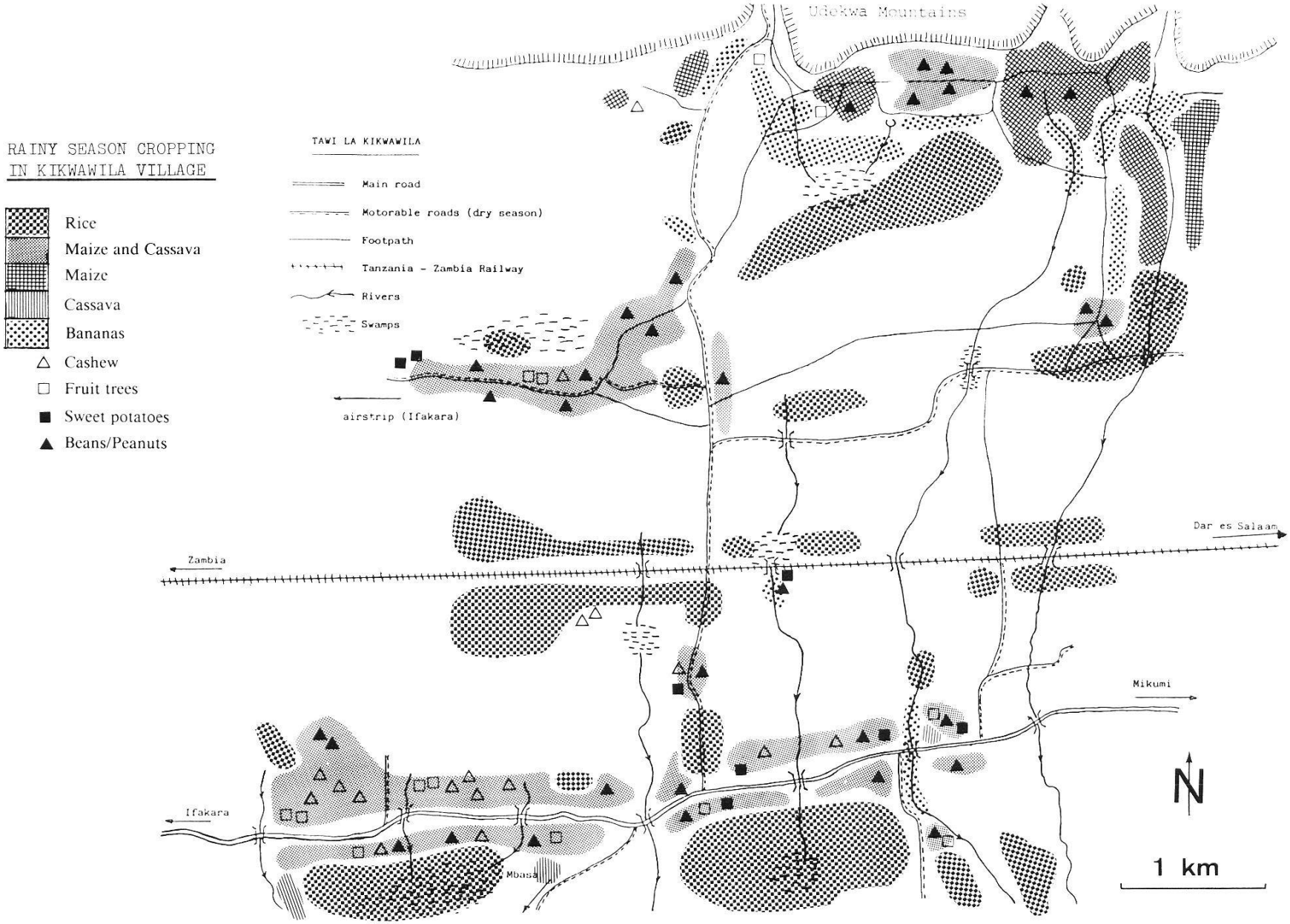

Fig. 4. Rainy season cropping in Kikwawila village in 1984 (from Zehnder et al., 1986).

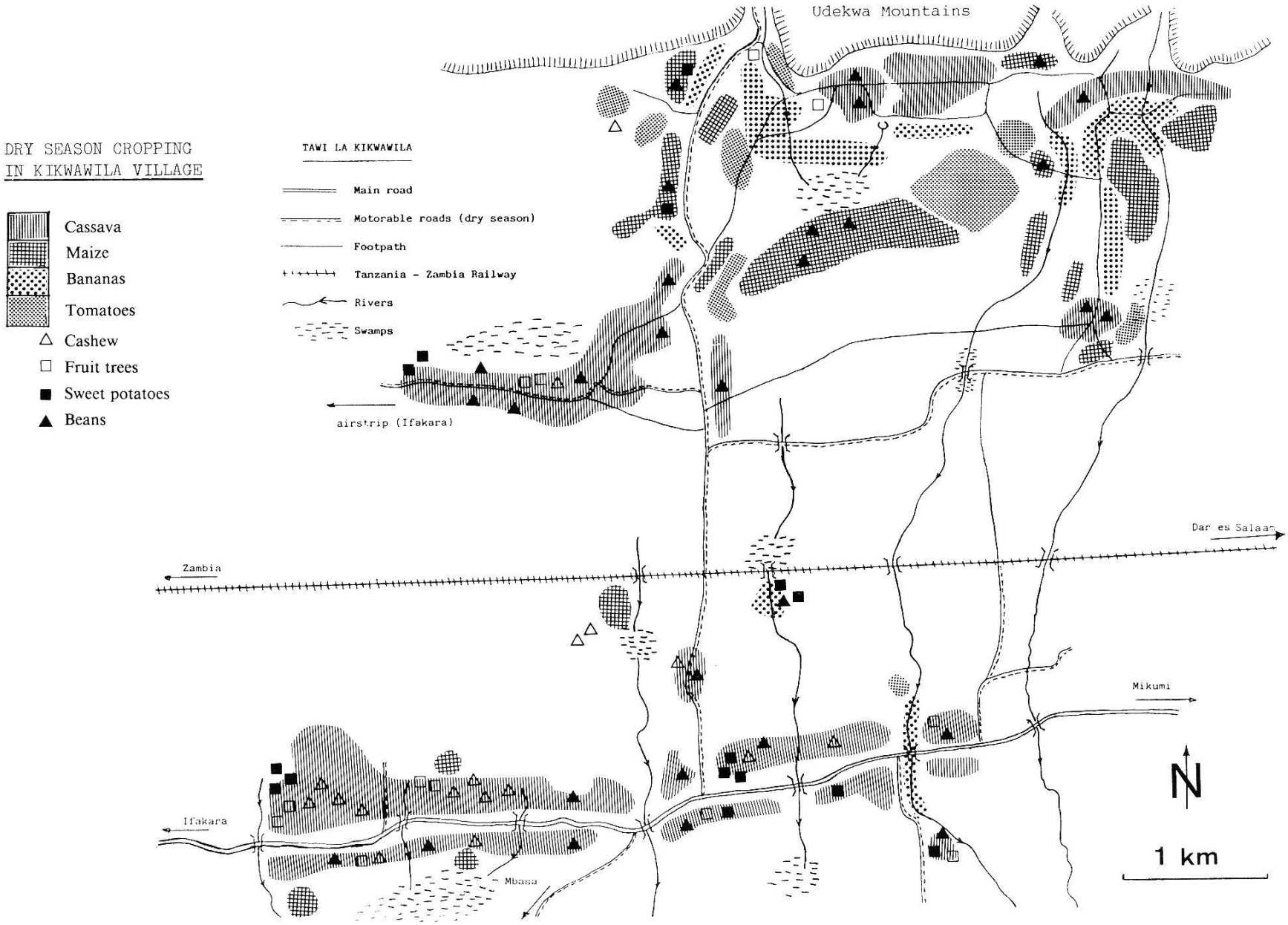

Fig. 5. Dry season cropping in Kikwawila village in 1984 (from Zehnder et al., 1986).

most habitations, the importance of which should not be underestimated as they played an important role in the diet of the villagers (Tanner and Lukmanji, 1987; Stürchler et al., 1987).

Production methods

Out of the 363 fields cultivated by the 100 households surveyed, 319 (88%) were fields already used the previous year and only 44 (12%) were prepared anew for the planting season 1983/84. Neither crop rotation nor fallowing were systematically practised in Kikwawila, most likely a consequence of increasing population density (Tanner et al., 1987b). Presumably this will lead to an impoverishment of the soil. Leguminosae were not found to be used as cover crops which can provide protection against heavy rains (= erosion) or drought (= loss of humidity). In addition, leguminosae could improve the soils through better nitrogen fixation and could also serve as green manure/mulch.

The preparation of the fields started with cutting grass with machete-like tools (jengo, panga), the grass then being set afire. Only the Wahehe tribespeople at Kilama saw grass as fertilizer and used it for mulching. The vast majority of fields were prepared with the hoe, only 7% of all fields being ploughed by tractor.

The preparation of seedbeds depended on soil quality and on the crops to be cultivated. More fertile soils were generally left with flat seedbeds, used most often for rice and seldom for cassava. Poor soils were frequently laid out in ridges and hillbeds, permitting a concentration of organic matter by working grass and weeds into the ridges. This practice was very commonly used for cassava.

The seeds were produced almost exclusively by the farmers themselves, i.e. by selection from previous harvests. Only 1.5% were provided by agricultural authorities and this small quantity was frequently inadequate for the local conditions.

Intercropping was found to be popular, the proportion of intercropped fields varying from 5% in the Kilombero riverplain to 72% in Lower Kilama. Out of 156 intercropped fields (43%), 123 were cultivated with two and 33 even with three crops, the most common combinations being maize and cassava, or maize, cassava and beans, respectively.

Soil preparation and weeding during growth were again done with the hoe, sometimes rather late in the season, or even too late to allow growth of the crop at all. The weeds were left lying on the ground or put into the ridges. Beside some remains of previous crops no other fertilizers were applied or available.

Natural irrigation of the fields occurred in the Kilombero riverplain, along the railway and in the plain south of Upper Kilama. Artificial irrigation was practised in Upper Kilama, allowing dry season cropping of rice, maize and tomatoes. This irrigation system consisted of a network of hand-dug channels, connected to two trunk channels which were fed by the Kilama river.

It is worth mentioning that production methods seemed to be determined rather by the soil quality than by tribal customs as had been described earlier (Jätzold and Baum, 1968). One notable exception are the Wahehe, who do not burn the grass but use it for mulching, and who introduced and maintained the artificial irrigation system mentioned. Whether the Wahehe just happened to colonize an area which called for the development of more sophisticated methods or whether they chose the Upper Kilama are because it was where they could apply some of their own traditional methods, remains open to question.

Yields and losses

One of us (B. J.) gathered information from 40 randomly selected households of the 100 surveyed households based on standardized interviews (see Zehnder et al., 1986). The average yield per household consisted of three bags of rice and one bag of maize (1 bag equal to 90 kg) from the rainy season harvest. This corresponded to an average productivity per acre as low as 1.5 bag of rice and 0.7 bag of maize. Dry season maize harvest significantly improved the situation only where artificial irrigation was in use. These yields established by interviews were extremely low and certainly did not reflect the actual yields which we estimated as four to five times higher according to our observations. The farmers did not like to state their yields since a significant proportion of the agricultural production is usually sold on the «parallel market», instead of to the national authorities. Furthermore, rice and maize were used to prepare local brews, «pombe». Marketing on the parallel market and brewing of maize and rice occurs during the post-harvest season, irrespective of the fact that the agricultural production hardly meets the needs of self-subsistence. It was done to generate cash for essential commodities such as soap, salt, oil, etc.

The major causes for losses in the fields were considered to be untimely heavy rains and, to a lesser extent, damage by animals and pests. 62% of the total of 363 fields surveyed were found to be damaged by animals such as elephants, various antelopes, bush pigs, baboons, bamboo rats and a variety of birds. As for pests, in about half of all rice and maize fields stemborers were reported, in roughly a quarter of the fields mites were observed on cassava, beside mosaic virus and scales. In nearly three quarters of the tomato fields, fungus (*Phytophtora*) and armyworms were found, and aphids were frequent pests of beans.

Crops were stored preferably inside the living houses (55%) and less frequently in separate storage constructions (45%), either huts on poles or earthen (laterite) silos. Due to the fact that in the year of the survey there was little to be kept in store, losses at household level were significantly less important than those in the fields.

Agricultural workload and farmers' sources of income

No detailed analysis was made of the number of working hours spent for the various agricultural activities and neither was their distribution investi-

Table 3. Seasonal distribution of major agrictultural work load at Kikwawila village in 1983/84

		Rice r	Maize m	Cassava c	Beans b	Tomato[1]	Weeding	Game/Bird watching
"Small rains"	Dec.	▽	▽	▽▲	▽		r m c b	c
	Jan.	▽	▽	▽▲	▽		r m c b	m
	Feb.	▽		▲			r m c b	r m c
"Big rains"	March						r m c b	r m c
	April		▲				r m c b	r m c
	May		▽			▽	m c b	r m c
	June	▲	▽			▽	m b	r m c b
	July	▲				▲	m	r m c b
	Aug.	▲	▲			▲		r m c b
	Sept.				▲			m c b
	Oct.		▲	▲	▲	▲		m c b
	Nov.			▲	▲			m c b

[1] at Upper Kilama only
▽ = plant, sow
▲ = harvest

gated among the sexes and the age group. A direct comparison of an individual's health status with work performance and productivity was therefore not possible in the frame of this study. Table 3 attempts to indicate when farmers were most busy in the 1983/84 agricultural year, but the labour of preparing the fields for the following cultivation period is not shown. Work commenced in October 1984 for rice, maize and cassava alike. Rice thus kept people busy from October to August, maize from October to April or, where dry season cropping was added, through to November, and cassava from October to February.

The growth of tomatoes in Upper Kilama was made possible by the introduction of (work intensive) artifical irrigation, and the labour involved fitted in well with other dry season activities. Table 3 also shows that weeding and protection of crops against game and birds took up a substantial part of the time available. Game defense activities – including night-time game watching by men and day-time bird watching by women and children – served as a suitable indicator for the presence of growing and maturing crops.

Not more than 12% of all households surveyed stated that they sold some of their food crops, these being mainly tomatoes grown in Upper Kilama. Non-agricultural sources of cash were employment in public services, as labourers on construction sites and other farms (15%), fishing in the Kilombero river during dry season (14%), and the sale of manufactured bricks or some handicrafts (6%). Animal husbandry was marginal and concerned but a few chickens, ducks or occasionally pigeons. Thus, 53% of the households claimed to have no regular cash income whatsoever. As mentioned earlier, this proportion seems definitely underestimated, as direct observations (see also Lukmanji and Tanner, 1985) –

in contrast to interviews – showed that most families sold some rice or maize or were at least brewing «pombe».

Discussion

The results presented are based on a limited number of observations and interviews held during slighthly more than one year, i.e. in the period of a single dry and a single rainy season. In addition, the rainy season 1983/84 brought large quantities of rain in December 1983 and January 1984 (Tanner et al., 1987b) as compared to the average (Freyvogel, 1960). The yields obtained in 1984 may therefore have been exceptionally low. Thus, the conclusions reached, although fully valid for the period of the investigation, may not be representative for other years without some caution. Yet the general impression about subsistence agriculture as observed in Kikwawila village tallies well with the overall findings of previous authors (Jätzold and Baum, 1968) and explains the seasonal variation in food deficiencies reported elsewhere in this volume (Tanner and Lukmanji, 1987).

Whether a farmer's household exclusively follows the wet season cropping pattern or whether it follows the wet and dry season pattern (Zehnder et al., 1986), depends largely on the quality of the soil and the availability of water. The majority of people who live in Kikwawila and Kapolo and cultivate non-alluvial soils without irrigation possibilities in the dry season, will adopt the first pattern and go fishing or look for work in the less favourable season. People at Kilama, particularly at Upper Kilama near the mountains, who live in the vicinity of streams on alluvial fans and have developed artificial irrigation, will follow the second pattern, which permits them to market parts of their yields and produce some additional crops like tomatoes.

This investigation, then, demonstrated that the people concerned are capable of adapting to local conditions, irrespective of tribal origin and that they are skilled, imaginative and assiduous agriculturists. The local conditions on the other hand, are clearly of limited potential, the soil being very mixed and water being scarce in places and unpredictable in time. In addition, although not all arable land is occupied yet, the human population density is comparatively high, particularly in Kikwawila, and is still rising (Tanner et al., 1987b). The possibility of fallowing is therefore decreasing and the danger of further impoverishment of the soil increasing. Thus, five interrelated elements ought to be given priority with the aim of improving the agricultural situation in Kikwawila village:

- soil conservation (crop rotation, promotion of leguminosae),
- soil enrichment,
- seed production (or appropriate seeds to be made available),
- timely crop husbandry,
- crop protection.

Earlier preparation of fields, early weeding, mulching rather than burning, covering fallow fields with leguminous cultures (e.g. *Crotalaria* spp.), extending the ridge-furrow seedbed system, rotating crops, intercropping more extensively (e.g. with the well adapted cowpea *Vigna unguiculata*), and rendering adequate seeds and seedlings available (including fast growing fire wood species) are some measures which could be applied in the specific area of Kikwawila village. These would contribute to protecting the ground against erosion and drying out alike, increasing its organic content, facilitating nitrogen fixation, improving aeration of soil and roots, enhancing plant tolerance of drought and resistance against pests and disease and, last not least, decreasing the daily workload, especially that of women.

How such measures are to be most effectively implemented needs careful consideration lest they become counterproductive. No time-consuming methods ought to be advertised unless a detailed workload analysis has demonstrated what changes, and to what extent, might be acceptable to which segment(s) of the household communities. In addition, a future workload analysis should be combined with the data on the health status; the impact of multiparasitism and other concomitant diseases that are prevalent among the population of Kikwawila (Tanner et al., 1987a) needs to be related to the food consumption and food production patterns that are observed at household level. Such data combined with the five agricultural priorities mentioned above will help to determine the long-term measures that might lead to improved food production in Kikwawila village.

Bearing in mind the existence of the national agricultural extension services (Ministry of Agriculture, 1983), Zehnder et al. (1986) have proposed the instalment of «Community Agricultural Workers» (CAW) who would serve as the (still missing) link between the extension officers («bwana shamba», responsible for one ward) and the farmers' communities, in a similar capacity to the village health workers (VHW) in the health sector (STIFL/DHO, 1985). Previous experience in the health sector has indicated that perequisites for community participation can be assessed and participation attained in these rural communities (Tanner et al., 1986).

It is suggested that CAWs be elected by the villagers, from among themselves, suitable candidates being well respected, long established farmers who are well aware of the local agricultural problems. They would remain part of their communities, applying improved methods on their own fields as well as on demonstration plots in various sectors of the village and should undergo short training and periodical upgrading courses held at ward and/or district level and presented by the District Agricultural Officer and his staff. These, in turn, would collaborate with other national institutions, e.g. the Tanzania Agricultural Research Organisation and the Tanzania Food and Nutrition Centre.

The strengthening of the agricultural extension service was recognised as a priority in the new agricultural policy (Ministry of Agriculture, 1983) and may

also contribute to raising food security and, more generally, to raising community health status.

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