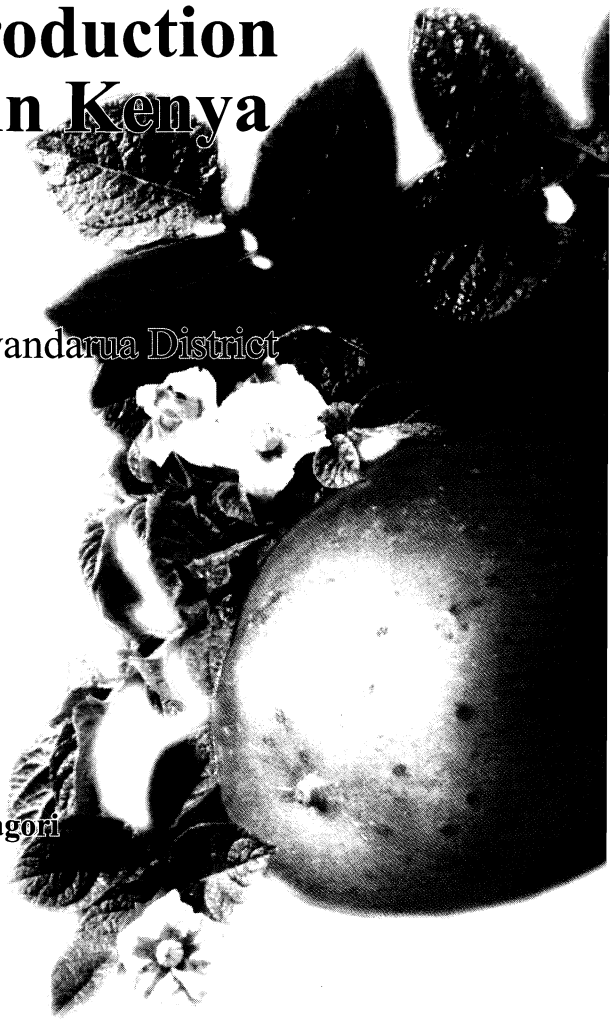
Food and Nutrition Studies Programme

Horticultural Production and Marketing in Kenya



Part 2A:
Horticultural Production in Nyandarua District

T. Dijkstra & T. D. Magori

Report No. 47/1992

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Abbreviations

ADC	Agricultural Development Corporation
CBS	Central Bureau of Statistics
DDP	Dairy Development Programme (Ministry of Livestock)
FNSP	Food and Nutrition Studies Programme
FTC	Farmers' Training Centre
ICDC	Industrial and Commercial Development Corporation
KGGCU	Kenya Grain Growers Cooperative Union
MOA	Ministry of Agriculture
MPND	Ministry of Planning and National Development

Currency rates

1990: KSh 1= Fl 0.08; KSh 1= $ 0.04
1992: KSh 1= Fl 0.06; KSh 1= $ 0.03

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Summary

Nyandarua is one of the five districts of Central Province, Kenya. Two-thirds of the area is suited for horticulture. Approximately 70% of the rural population live in those parts. In 1990, a farm survey was carried out among 240 rural households in eight sub-locations to study the production of vegetables, fruits and cut-flowers.

The district farmers have developed a flourishing horticultural industry ever since their settlement less than half a century ago. Almost all studied households grow vegetables, with over 90% of them selling part of the harvest in 1990. The vegetables on average accounted for about half the household net income and cash revenues, with livestock being the second major source. Off-farm employment contributed to some extent, while pyrethrum and fruits hardly counted in terms of money.

Potatoes are by far the most important vegetable. Two-thirds of the harvested bags consisted of potatoes in 1990, while the crop generated three-quarters of the average vegetable income and cash revenues. Other important crops are cabbages, green peas and spring onions, although commercial production of the latter commodity is mainly restricted to Geta location.

The most common fruits are plums and pears. Their production had earlier been promoted in the 1970s, but nowadays lack of market outlets prompt farmers to neglect the trees and feed the fruits to the cattle. Apples, which might serve as an alternative, were only grown by a small group of farmers in 1990.

Inputs like fertilizers, pesticides, hired labour and hired tractor services are quite common in vegetable production. Insufficient use of certified seed in case of potatoes, however, causes bacterial wilt, while fertilizer applications below the recommended levels affect the fertility of the soil in the long run.

For the moment, the most important problem faced by the farmers concerns increasing input prices. Between 1990 and 1992 the costs of for instance fertilizers and pesticides went up by two-thirds and more, due to scaling down of subsidies by the government and depreciation of the Kenyan Shilling. As a consequence, commercial vegetable production is no longer profitable along the lower slopes of the Aberdares and Bahati escarpment during most of the year. Farmers in those areas lost almost half their income out of horticulture within two years, leaving livestock as the major cash earner.

Farmers also have to cope with unpassable roads after heavy rains, which leave them with unsold produce and cause financial losses of a quarter to a third of their annual cash incomes out of vegetables. The Nyandarua road network, which serves one of the major vegetable producing districts of the country, does not seem to get the priority that it deserves. Improvement of the infrastructure is important in order to secure the supply of vegetables to the urban markets of Central Province, and hence the profitability of horticultural production in the district.

Other conditions for a successful future of horticultural production in Nyandarua concern market-oriented production and diversification by the farmers. The district extension services have to play an important role in both respects, backed by national agricultural research centres and credit institutions. Extension messages should be based on an integrated approach. Private stockists could play their part in disseminating the messages. Research should focus on alternative crops that can be grown in sequence with vegetables (like oil crops and fodder crops), promising fruits like apples, and cut-flower species for small-scale production. The national government should look into bottlenecks that occur through scarcity and quality deterioration of various types of vegetable seeds, and royalty payments in relation to small-scale floriculture.

Introduction

Kenya produces a large variety of horticultural commodities, including temperate and tropical vegetables, fruits and cut-flowers.[1] They originate from ten major horticultural production areas, situated in twenty-one of the forty-two districts of the country.[2] Most production is rainfed, but irrigated vegetable and flower cultivation can be found in some dryer parts of the Coast and Rift Valley Provinces. Vegetables and fruits are grown both for home consumption and for sales in order to generate income, while cut-flowers are only cultivated to sell. The large majority of horticultural commodities meet domestic demand, but some are exported to overseas markets.[3]

The importance of the horticultural sector as producer of food and source of income, employment and foreign exchange has been recognized by the Kenyan Government. According to the 1989-1993 National Development Plan, horticulture should be one of the major commodities to be promoted (GOK, 1989). District authorities have to play an important role in this respect, but many of them lack up-to-date information about horticultural production and marketing within their boundaries. The present study was therefore developed to cover major horticulture producing districts in various parts of the country.

The study, which is part of the Food and Nutrition Studies Programme, was undertaken by the Ministry of Planning and National Development (Nairobi, Kenya), Egerton University (Njoro, Kenya), and the African Studies Centre (Leiden, the Netherlands). The main objective was to study the production and marketing of horticultural commodities in selected Kenyan districts, with an eye to future improvements in Kenya in general and the districts concerned in particular. A comprehensive description of research

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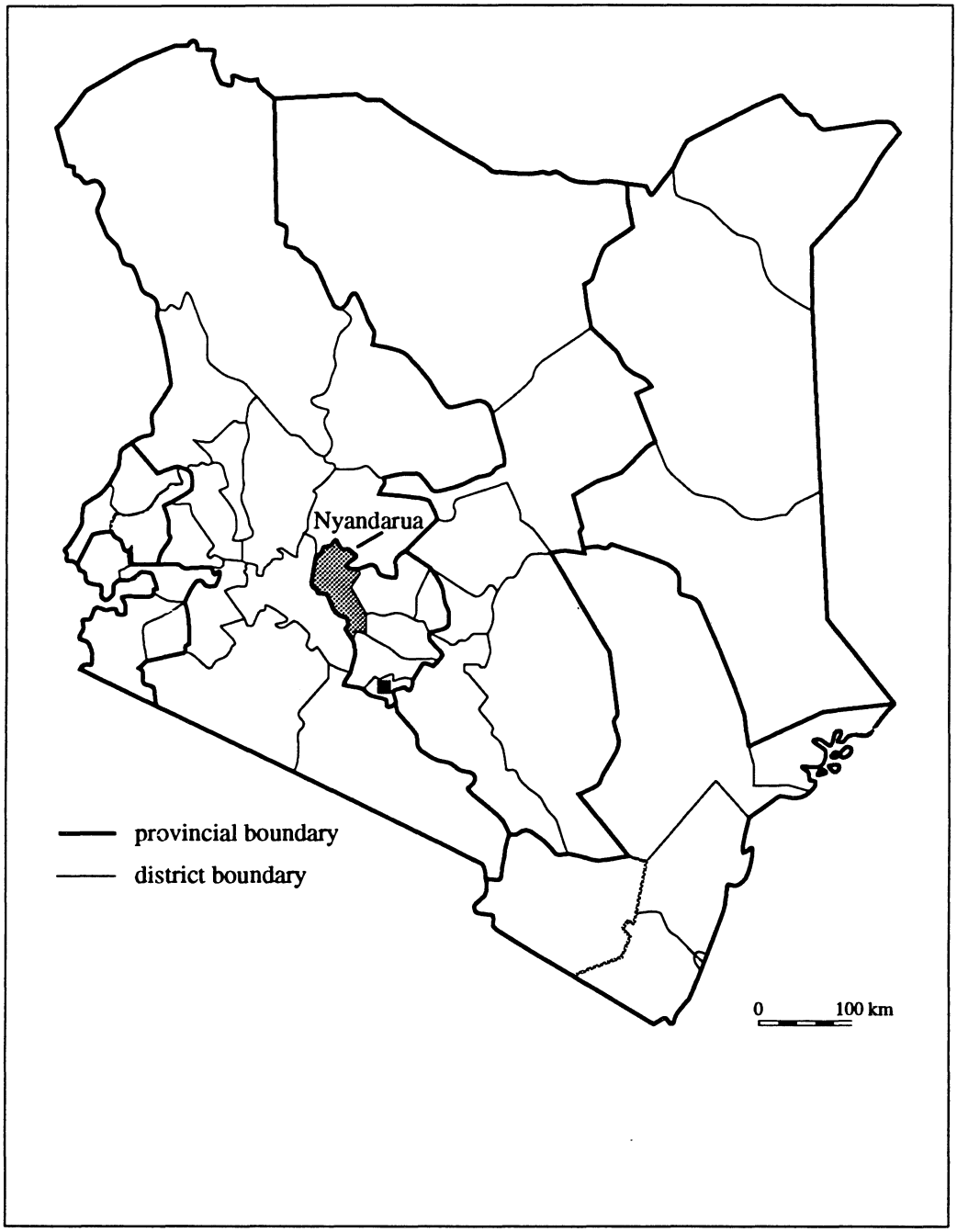
[1] See Dijkstra & Magori (1991), Appendix 1.
[2] See Dijkstra & Magori (1991), Table 2, p.12-13.
[3] See Dijkstra & Magori (1991), Appendix 2.

Map 1. Location of Nyandarua District, Kenya



questions and study design has been given in Part 1 of the series of reports.[4] The present report (Part 2A) deals with horticultural production in the pilot district, namely Nyandarua, which is one of the main suppliers of vegetables to the Nairobi market.[5] The next report (Part 2B) deals with horticultural marketing in the same district. The research results were discussed during a seminar with thirty district officials, farmers, and representatives from local government institutions in Nyahururu on 28 October 1992.

Chapter 1 of the present report presents the necessary general information on horticultural production in the district, together with a brief explanation of the methodology. The subsequent chapters discuss the results of the farm survey: Chapter 2 deals with household characteristics; Chapter 3 offers an analysis of household income; Chapter 4 specifies households' production and income from horticulture, while Chapter 5 presents a cost-benefit analysis of three important horticultural commodities. Finally, Chapter 6 offers conclusions and recommendations.

[4] Horticultural Production and Marketing in Kenya; Part 1: Introduction, Research Objectives and Methodology; by T. Dijkstra & T.D. Magori; FNSP report 41/ 1991.
[5] Map 1 shows the location of the district.

1. Nyandarua District

1.1. Introduction

Nyandarua is one of the five districts of Central Province, Kenya. The district lies between $0^{o}08'$N and $0^{o}50'$S latitude and between $36^{o}13'$E and $36^{o}24'$E longitude, covering an area of 3,528 square kilometers. It has a fairly elongated form. The Aberdare Range in the East serves as a natural boundary towards Nyeri and Muranga, whereas Nakuru district in the West covers the floor of the Rift Valley. The area in between consists of a series of descending fault escarpments.

In pre-colonial days most of the land was Masai territory, but during the colonial period European settlers took possession of the land to establish large-scale farms. After Independence these farms were subdivided by the Government into settlement scheme plots. Most of the plots were granted to one ethnic group, the Kikuyu. Nowadays, they make up 95% of the total population (MPND, 1989d). Among the other ethnic groups are Kalenjin, Luhya, Luo, Turkana and Kamba.

According to CBS estimations, the district was expected to attain a population of approximately 327,400 persons in 1990.[6] This implies a population density of 98 persons per square kilometer, which is rather low in comparison to the other districts of Central Province.[7] Nyahururu and Ol Kalou, the only urban centres, house 6% of the district population.[8]

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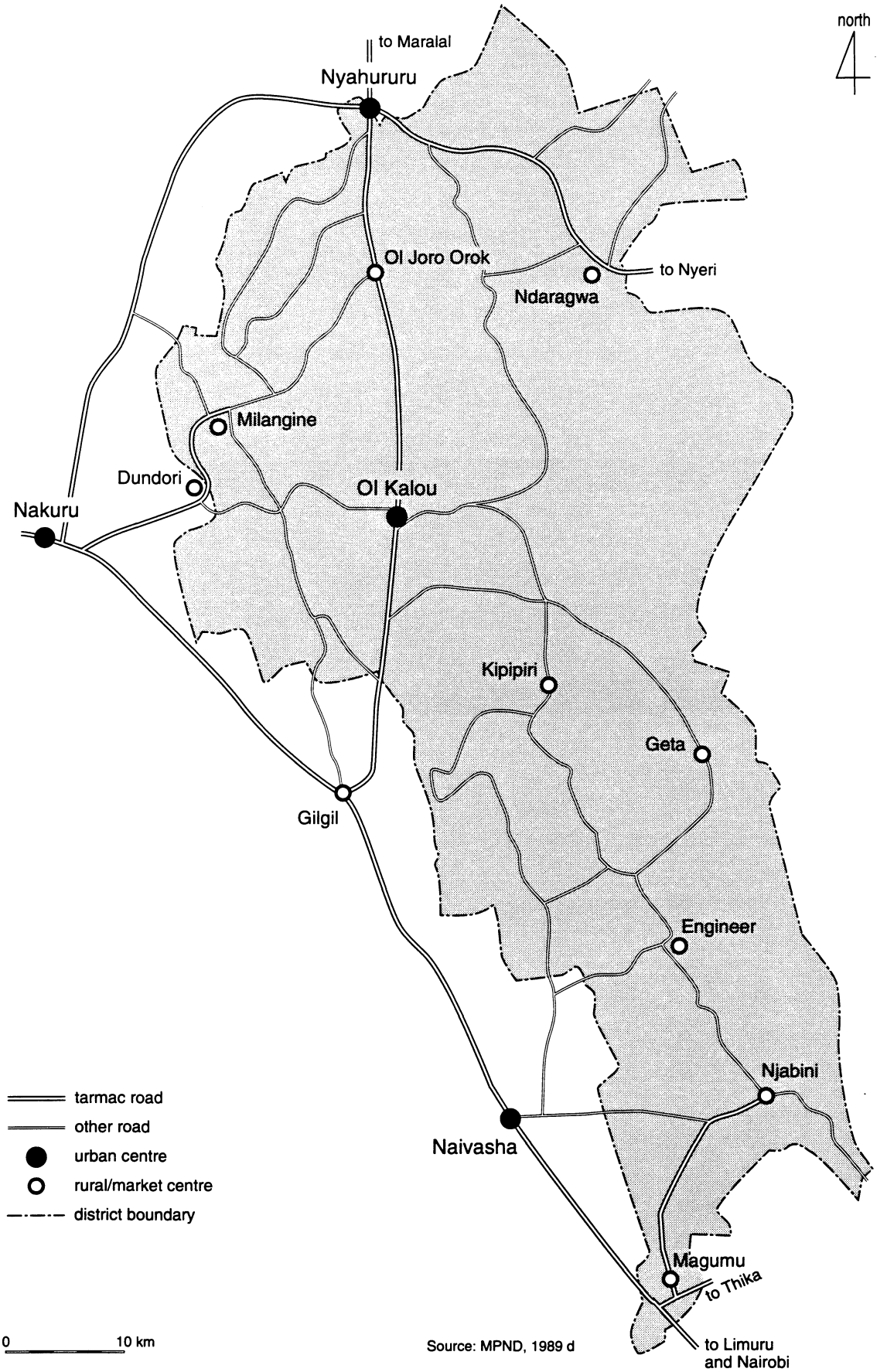
[6] Based on the population census of 1979 (233,302 persons at that time), a fertility rate of 3.2% and a declining infant mortality rate in the district (MPND, 1989d).

[7] Compare: Kiambu 448 persons per sq km (MPND,1989a), Nyeri 224 persons per sq km (MPND,1989e), Muranga 412 persons per sq km (MPND,1989b) and Nakuru 135 persons per sq km (MPND, 1989c). The figures are estimates for 1990.

[8] The term urban centre denotes the presence of a town council in the locality.

Map 2. The road system of Nyandarua District



The physical infrastructure of the district has always suffered from the heavy precipitation. Traffic has the use of three tarmac roads. The only inter-district road, which crosses the North and North-West of Nyandarua, connects Nyahururu with Ndaragwa and Nyeri on the one hand, and Ol Kalou and Gilgil on the other (Map 2). At Gilgil it joins the Nairobi-Nakuru highway. Two short outward-bound roads link Njabini and Milangine with the same highway through Magumu and Nakuru respectively. The location of the tarmac roads excludes the central belt and upper slopes of the Aberdares. These areas can only be reached over one of the many feeder roads, which are, however, often impassible during the lengthy rainy seasons. Locations like Engineer, North Kinangop, Kipipiri, Geta and Shamata are often cut off from the outside world in times of heavy rainfall.

1.2. Agro-ecological zones

Nyandarua lies between 1,828 and 2,437 meters above sea level and is part of the Kenyan highlands. Based on altitude, rainfall, temperature and soil types, the district can be divided into different agro-ecological zones (Jaetzold and Schmidt, 1983). Over 75% of the area is classified as upper highland zones.The remaining part, that is the Southern half of the central belt and the area north of the Nyahururu-Nyeri road comprises offshoots of the lower highland zones in Nakuru and Laikipia Districts. Map 3 shows the different zones; Table 1 specifies the characteristics of each zone.

Precipitation is greatest on the upper slopes of the Aberdare Range and the Bahati escarpment, that is in the UH1 and UH2 zones.[9] It is well spread over the year and quite reliable, as is shown in Figure 1 by the average and "60% reliability" rainfall. The latter figure is of importance because risk-avoiding farmers do not base their agronomical calender on averages but on the chances of sufficient rainfall. This is indicated more realistically by the minimum rainfall in 6 out of 10 years. The larger the difference with monthly averages, the less reliable the rainfall. In the UH1 and UH2 zones the difference is small, as is shown by the two first graphs of Figure 1. Thanks to the regularity of rainfall, vegetables can be cultivated over a period of nine months or more, which implies

[9] This also includes the Tropical Alpine (TA) zones and Forest zone (UH0), but they are not relevant to our discussion as they are situated within the Aberdare National Park (TA) or forest reserve (UH0).

Map 3. Agro-ecological zones in Nyandarua District

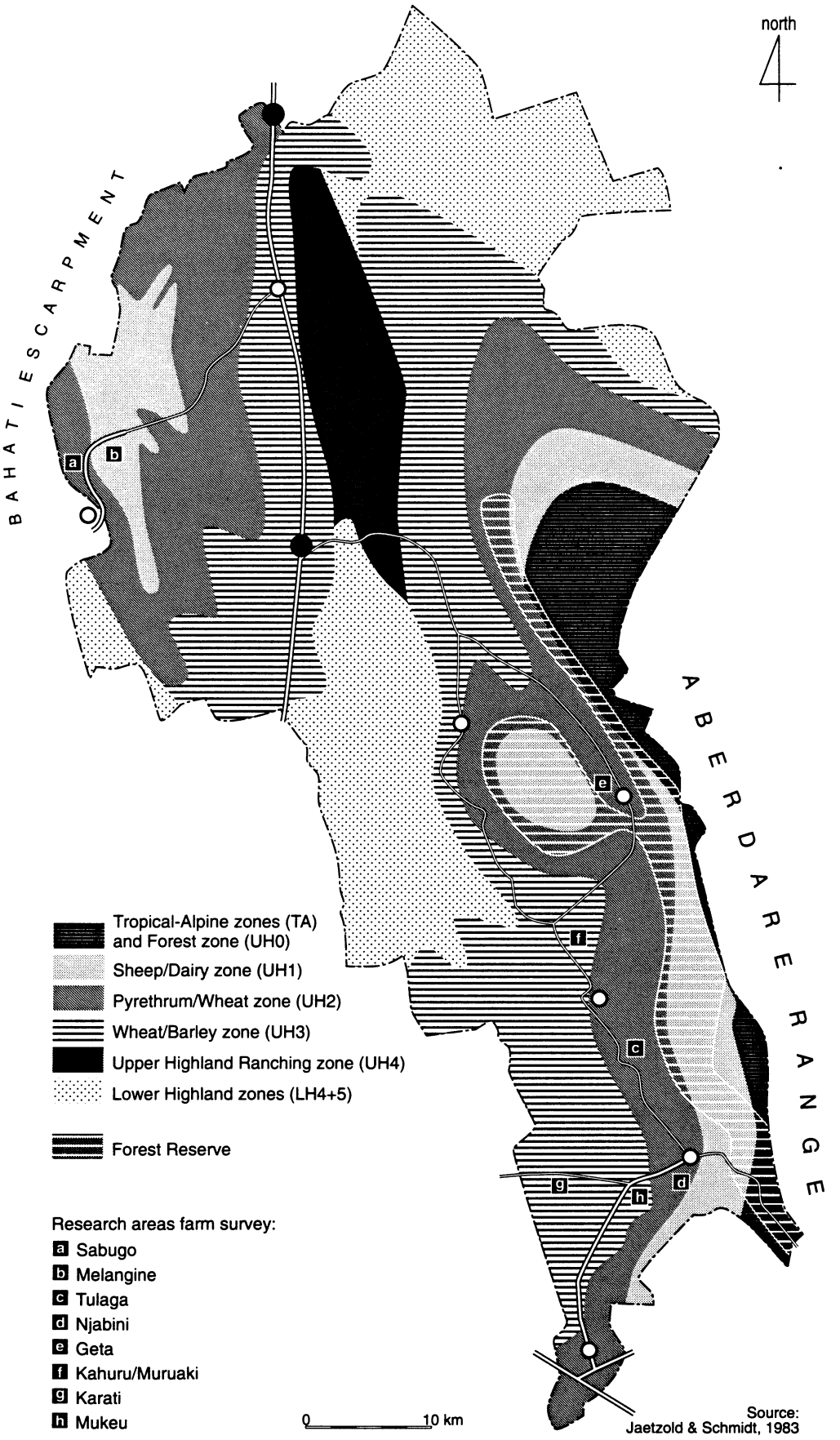


Table 1. Agro-ecological zones and their characteristics in Nyandarua district

Zone	Altitude (m)	Rainfall (mm/year)	Cropping seasons	Horticultural commodities		Other commodities	
				Good yield potential	Fair yield potential	Good yield potential	Fair yield potential
Tropical Alpine Zones (TA) and Forest zone (UH0)	>2740	>1500	National Park/ Forest				
Sheep-Dairy Zone (UH1)	2400-3000	1150 - 1600	permanent cropping possibilities, divisible into a long to very long and a medium cropping season	except for the steep and upper slopes: potatoes,peas,cabbage, carrots,kohlrabi,celery, radish,endive,leek, spinach		oats,rapeseed	(maize)(1)
Pyrethrum-Wheat Zone (UH2)	2400-3000	950-1200	very long to long or two cropping seasons (with intermediate rains)	potatoes,peas,cabbage, carrots,kohlrabi,celery, radish,endive,leek, spinach,kales	pears,plums, apples (below 2600m)	pyrethrum, wheat, barley, oats,rapeseed, horse beans	(maize)(1)
Wheat-Barley Zone (UH3)	2370-2430	800-1100	weak very long to long or two weak cropping seasons (with intermediate rains)	(potatoes),(shallots), (cabbage),(kohlrabi), (cauliflower)	potatoes,(carrots), (shallots),(cabbage), (peas),(cauliflower), (kohlrabi)	(wheat),(barley), (rape/linseed), (flax)	(pyrethrum), (wheat),(barley), (rape/lineseed), (sunflower), (oats),(maize)(1)
Upper Highland Ranching Zone (UH4)	2280-2370	850-950	unimodal rainfall with intermediate rains	not suitable for agriculture due to low rainfall and frequent night frosts			
Lower Highland Zones (LH4 and LH5)	2070-2280	750-950	weak long or three weak very short cropping seasons	only suitable for rainfed agriculture in case of a weak long cropping season	(potatoes),(shallots), (tomatoes)		(wheat),(barley), (sunflower)

Source:Jaetzold and Schmidt, 1983.
Note: in case of brackets the rain or crop only applies to part of the zone.
(1) only very late maturing maize on frost-free places.

for instance three successful potato harvests a year. Temperate fruits do well up to an altitude of 2600 meters.

The soil on the slopes is loamy, with high fertility on the Aberdares and low to moderate fertility on the Bahati escarpment. Part of the upper slopes of the former are covered by forest reserve. Inside the reserve the soil is often shallow and very sensitive to erosion. Surface run-off has already become a problem in various parts of the zones.

When descending the slopes of the Aberdare Range and Bahati escarpment, precipitation decreases but remains scattered throughout most of the year. In the upper parts of the UH3 zone the average rainfall is still considerable during some months, but with low reliability (Figure 1; Nyahururu). As a consequence agricultural production becomes more hazardous. In the lower parts of the zone both the average and 60% reliability figures are low (Figure 1: Ol Kalou). Farmers in the UH3 zone still grow two crops a year (some even try three), but in most cases the yield potential is only fair (Table 1). Fertility in the UH3 zone ranges from low to moderate in the southern and north -western part of the district and from moderate to high in the North -East. The latter area, however, has to cope with shallow soils. Crop cultivation in the southern area can be hampered by periodic waterlogging.

Further down, that is towards the central belt of the district, the area becomes almost completely unsuited to agricultural crops. The clayish soil in the UH4 zone is quite fertile, but lack of rain, frequent night frosts, and waterlogging near Lake Ol Bolossat are severe disadvantages.[10] In the lower highland zones (LH4 and LH5) lack of rainfall, variable fertility and shallowness of the soil hamper agricultural production. Both the UH4 and lower highland zones are mainly used for ranching, with the exception of some parts of the LH4 zone where cereals and small quantities of vegetables are grown.

It can be concluded that agricultural production is mainly restricted to the UH1, UH2 and UH3 zones in Nyandarua. The UH1 zone has a good yield potential for horticultural crops, with the exception of the forest reserve and the steep and upper slopes. The UH2 and UH3 zones are suited to cultivation of horticulture, pyrethrum and some cereals, with

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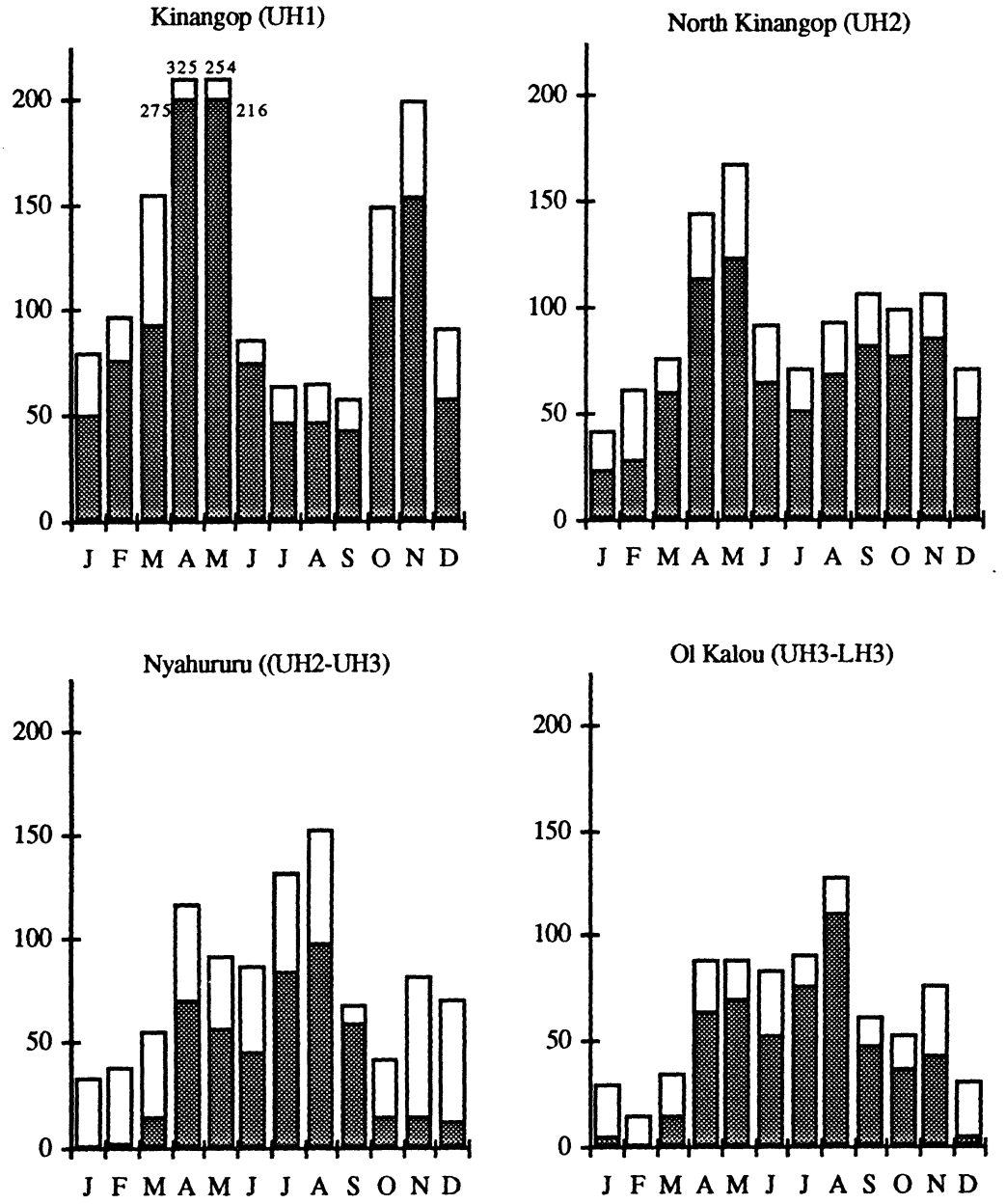
[10] Lake Ol Bolossat is situated half way between Ol Kalou and Ndaragwa. In the past an official settlement scheme was established within the catchment area of the lake on the eastern shore. However, the farmers used too much water for irrigation and therefore endangered the existence of the lake. Subsequently, the government moved most of the farmers to other places again while forbidding the remaining ones to grow irrigated crops.

Figure 1. Rainfall in different agro-ecological zones (cm/month)



Based on Jaetzold and Schmidt (1983)
Notes: The whole boxes (including white and shaded parts) represent monthly averages, and the shaded boxes only the monthly rainfall surpassed in 6 out of 10 years. The figures are based on at least 25 years of records up to 1976.

good yield potential in the former zone and fair in the latter. However, crop cultivation in the UH3 zone can be hampered by less reliable rainfall, waterlogging and shallow soils.

The UH1 zone covers 7% of all agricultural land in the district, against the UH2 and UH3 zones with 30% each (Table 2). The three zones, which we call the horticultural zones, are not equally distributed over all divisions. Kinangop is best provided with Upper Highland zones, both absolutely and percentage-wise. Second to fourth in the hierarchy are Ol Kalou, Ol Joro Orok, and Kipipiri, whereas Ndaragwa is last with two-thirds of its area consisting of Lower Highland zones. When looking at the population, 70% of the rural population live in the horticultural zones (see Appendix 1).

Table 2. Agricultural land by agro-ecological zone and division (sq.km.)

Division	*UH1*	*UH2*	*UH3*	*Other zones*	*Total*
Ol Joro Orok	25	150	62	73	310
Ol Kalou	63	169	112	182	526
Kipipiri	0	67	115	182	364
Ndaragwa	1	57	94	239	391
Kinangop	62	199	253	10	524
Total	151	642	636	686	2115

Source: Jaetzold and Schmidt, 1983
note: The figures for Kipipiri division are updated (see Appendix 1).

1.3. Horticultural production

Acreages, values and yields

In 1990, 57,034 ha or 16% of the district area was actually used for agricultural purposes. Cereals and horticulture each claimed about two-fifths of the land under cultivation (Table 3). The share of horticulture was quite high compared to other districts. Farmers in Kiambu District, for instance, who are the biggest suppliers of horticulture to Nairobi, grow vegetables and fruits on one-quarter of the cultivated land.[11] The importance of horticultural production in Nyandarua District is also shown by the value of the crops produced. The total value of vegetables and fruits was KSh 20.5 mln. in 1990, against KSh 5.7 mln. worth of cereals and KSh 2.6 mln. worth of pyrethrum.[12]

[11] In 1987, the area under horticultural crops in Kiambu District was 24,083 ha (MPND, 1989a).
[12] Appendix 2 specifies the values of the various types of cereals, vegetables and fruits.

Table 3. Cultivated area by commodity (ha.)

	1985	*1986*	*1987*	*1988*	*1989*	*1990*
Maize	19,816	20,350	17,800	18,640	19,520	20,011
Wheat	2,122	2,920	1,875	2,720	2,960	3,345
Barley	-	-	-	-	156	155
Cereals total	21,938	23,270	19,675	21,360	22,636	23,511
Beans	3,565	5,670	3,640	5,660	5,250	5,360
Lime beans	420	130	330	250	390	340
Pyrethrum	4,013	4,230	2,810	2,970	3,175	4,480
Sunflower	-	-	-	-	115	35
Potatoes	12,523	13,575	8,600	13,000	12,000	11,520
Peas	4,830	5,350	4,700	2,840	4,286	4,290
Cabbages	5,730	5,950	4,250	4,500	4,800	4,730
Carrots	606	1,150	920	870	950	1,023
Kale	497	564	500	550	560	572
Onions	78	152	165	260	200	293
Spring onions	531	350	145	350	388	360
Vegetables total	24,795	27,091	19,280	22,370	23,184	22,788
Plums	384	384	390	395	389	359
Pears	67	68	67	67	70	70
Apples	39	40	40	45	48	51
Peaches	11	12	12	12	13	13
Citrus	1	-	-	12	13	13
Tomatoes	14	-	-	2	8	14
Fruits total	516	504	509	533	541	520
Grand total	52,247	60,895	46,244	53,143	55,291	57,034

Source: MOA, 1989b; MOA, 1990; MPND, 1989d

The cultivated acreages of all agricultural commodities crops fluctuate from one year to the next, as do the yields per acre. Both fluctuations are related to weather conditions. Frost, hailstorms, and failing or excessive rains hit the district regularly. In 1987, for example, the yields of major crops including horticulture dropped by as much as 30-35% compared to 1986 due to waterlogging, erratic inadequate rainfall and frost. Potatoes were targeted at 14.2 ton per hectare, while only 9.7 ton per hectare was achieved (MOA, 1987). Frost remained a problem in the following years, combined with an early onset of rains in 1990 which interfered with land preparation (MOA, 1989b; 1990).

Potatoes, peas and cabbages accounted for 88% of the area under horticulture in 1990 (Table 3). The remaining 12% was shared by other vegetables (10%) and temperate fruits (2%). Vegetables like kohlrabi, celery, radish, endive, leeks, spinach and cauliflower, which were mentioned in Section 1.2 as crops with good yield potential, do not appear in Table 3 at all. Since their absence cannot be explained agro-ecologically, it has to be related to other factors. One of them is the lack of seeds at the local stockists. Another is

farmers' lack of market information about supply and demand conditions in the urban markets. Both factors need the attention of the District agricultural staff.

We will come back to the questions of diversification, input supply and market information in the coming chapters. For the moment three horticultural commodities will be discussed because of their specific histories, namely carrots, plums and cut-flowers.

Carrots

The history of carrot production in Nyandarua was rather unexciting until 1986, when Pan African Vegetable Products Ltd, the owner of a vegetable dehydration plant in Naivasha, (re)started a promotion campaign for carrot cultivation in Kinangop division.[13] The company supplied carrot seed on credit to the farmers through their cooperative societies.[14] Moreover, the farmers were promised a guaranteed market outlet and the company would take care of transport to the factory. So far so good, until the factory trucks did not turn up when the carrots had been harvested. Farmers who organized transport to Naivasha themselves had to cope with further difficulties. The carrots had to meet all kinds of requirements. They were supposed to be of a certain size, colour, moisture content, variety, and topped off in a particular way. Last but not least the prices the farmers were offered were low compared to prices in the market for fresh carrots, while not receiving cash on delivery. As a consequence many farmers stopped carrot cultivation altogether while others focussed on the market for fresh produce through middlemen from Nairobi.[15]

Plums

The history of plum production is somewhat similar to that of carrots. In the 1970s, plum and to a lesser extent peach cultivation was promoted extensively by different fruit processing factories in Central Province, of which Kenya Orchards in Machakos was the most important one. The factories used to send representatives to Nyandarua District to inform divisional extension officers about the collection dates of the fruits. The officers

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[13] Appendix 3 briefly reviews the history of Pan African Vegetable Products Ltd.
[14] Many people, including farmers and government officers, thought and still think that the seeds were supplied free of charge.
[15] For up to date production data on carrots see Chapter 2.

then told the farmers where and when to bring their produce (e.g. Njabini or Geta). The fruits were used to produce jams, which were mainly exported to Zambia and Tanzania. From the second half of the 1970s onwards export became more difficult because of political tensions between the countries involved and the subsequent closure of borders. The factories stopped sending representatives to the district, so that the farmers were saddled with unsaleable fruits (few people liked to eat them fresh). Some farmers jointly hired a pick-up to take their produce to the factories, but they were confronted with tough grading and low prices. Ever since, the production of plums and peaches has been ailing. Most farmers have not uprooted their fruit trees, but neglect them and harvest only for own consumption, for cattle fodder or to sell in small quantities to middlemen from Nairobi. The latter sell the fruit to jam factories producing for the small local market and to a limited group of urban consumers who eat them fresh.[16] Now and then, a jam factory discovers a new market outside the country and starts to stimulate farmers again to harvest their fruits. Some farmers get so excited that they plant new trees. Often the export market is lost after some years and the old situation returns. The plum trees are neglected and the orchards get overgrown by weeds.

Cut-flowers

Cut-flowers are a relatively new but promising commodity in the district. Although the planted acreage did not exceed 60 ha in 1990 (MOA, 1990), the commodity was a major source of income to the farmers concerned. The number of small-scale flower growers was a little over 300 in 1992, nearly all members of the Kinangop Flower Growers Association. They produced mainly Alstroemeria, but also small quantities of Lilies, Moluccella (Bells of Ireland), Ammi major and Carnations.[17] All of them were originally meant for the export market but Carnations were no longer exported because of a global oversupply. The flower was sold by individual members in the Nairobi market. The other species were sorted and graded at one of the two grading stations of the association, after which they were bought by an export trader. The latter took care of packing and paid the farmers after some two weeks through their bank accounts.[18]

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[16] Expatriates are probably the most important urban consumers of jam and fresh plums.

[17] All production was rainfed. The output per member was about 5,000 to 10,000 stems per year. The total turnover of the association during the 1992/1993 season was estimated at 5 to 6 mln KSh.

[18] The biggest grading station, in Njabini, has a cold room were the flowers are stored until they are transported. The cold room is chilled by means of moistened charcoal. Before the flowers enter the cold room they are graded and bundled by employees of the association, after which they are checked and registered by a representative of the exporter. Once registered, the flowers belong to the trader who then bears the storage and market risks. The farmers are paid a fixed price, based on the average for the whole

Apart from small-scale production, one large-scale flower farm is operational in Kinangop Division, which is owned by Sulmac Co. Ltd, one of the leading flower exporters of Kenya. Sulmac introduced small-scale flower production in the district through an outgrower system, whereby farmers received inputs and in return sold their cut-flowers to the company. Results, however, were not altogether positive, as farmers could not meet the high quality standards.[19] Therefore, Sulmac, like other large-scale flower growers, reverted to fully controlled production on its own estates. At that time the Kinangop Flower Growers Association did not yet exist.[20] The activities of this loose cooperative have improved the quality of the small-scale production considerably, but many problems still remain.

Lack of appropriate planting material is the main problem in small-scale floriculture at the moment. Cut-flowers in the international market are subject to fashion, meaning that varieties which are in demand during one year may find no market at all a few years later. Moreover, European multiplication farms continuously develop new varieties that may not only have other shades of colour, but are also of a better quality. Those varieties are, however, expensive because of royalties, making their cultivation uneconomical to most small-scale growers at present.[21] The multiplication farms are also reluctant to deal with smallholders because of the hazards of controlling illegal multiplication and circulation of the material.[22] Small-scale producers are therefore always in danger of being pushed off the market.[23]

A second problem in small-scale flower cultivation is the present lack of credit facilities for the farmers to buy the necessary fertilizers, pesticides, preservation chemicals and

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season, in order to avoid the day-to-day price fluctuations of the international market. The season lasts from September/October to April/May.

[19] The stems need to have a specific length and straightness, the flowers have to be of a specific colour without any spots, and within the whole lot not one diseased specimen is allowed.

[20] It was established in 1990 and started it grading activities in 1991.

[21] The selling price of planting material by the European multiplication farms includes two cost factors, namely the research costs with regard to new varieties (the royalties), and the actual costs of multiplying the planting material. The price normally refers to a square metre of planted flowers, based on standardized spacing.

[22] The multiplication farms visit all large-scale flower farms that use their planting material several times a year in order to check on such illegal practices. Similar checking of a group of small-scale producers would be much more time-consuming.

[23] The members of the Kinangop Flower Growers Association for instance produced mainly the "Marina" variety of Alstroemeria in 1992, although it is an old variety that is going out of fashion. The leaders of the association were aware of this but did not know what to do about it.

nets. All are needed to improve the quality of the flowers, which is essential to secure the future market.[24]

A third problem is the inadequate technical knowledge about cut-flower cultivation among small-scale farmers and the district extension staff. The latter are often less knowledgeable than the flower growers themselves.

1.4. Methodology: the farm survey

Up-to-date information on horticultural production at farm level is scarce in Nyandarua District. A farm survey was, therefore, carried out to study the production of horticultural commodities. The specific research questions focussed on the economic aspects of the horticultural enterprise, including:

- the relative importance of horticulture in comparison to other sources of farm and off-farm income
- the relative importance of specific horticultural commodities
- the profitability of horticultural cash crop production
- the constraints on horticultural cash crop production

Part 1 of the series on horticultural production and marketing in Kenya explains the research methodology in detail (Dijkstra & Magori, 1991). First the areas within the district suitable for horticulture were identified. In Nyandarua they were the UH1, UH2 and UH3 agro-ecological zones. Subsequently, eight clusters were selected in those zones (Table 4).[25] The number of clusters per zone was related to the total number of households present.[26] The UH1 and UH2 zones were covered by five clusters (one of which in the relatively small UH1 zone), and the UH3 zone by three clusters. Map 3 (page 15) shows their locations. Within each of the eight clusters, thirty households were selected by means of systematic sampling with substitution. The households were interviewed by means of a standardized questionnaire (Appendix 4).[27]

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[24] Other developing countries like Tanzania are increasing the supply in the international market and thus intensifying competition. As a consequence quality standards rise.

[25] Existing CBS clusters were used.

[26] Appendix 1 shows the calculations of the population per zone. The number of households per zone was calculated by dividing the total population per zone by the estimated zonal average household size.

[27] Nyandarua served as a test case in this respect. The questionnaire appeared to work satisfactorily and needed only minor changes before being used in other districts during the main phase of the study. The up-dated questionnaire for the other districts can be found in Part 1 of the series (Dijkstra & Magori, 1991).

Table 4. The sampled clusters of the farm survey

cluster no	*Sub-location*	*Location*	*Division*	*zone*
313	Sabugo	Dundori	Ol Kalou	UH2
315	Melangine	Dundori	Ol Kalou	UH1
326	Tulaga	South Kinangop	Kinangop	UH2
327	Njabini	South Kinangop	Kinangop	UH2
328	Kahuru/Muruaki	North Kinangop	Kinangop	UH3
330	Karati	Nyakio	Kinangop	UH3
331	Mukeu	Nyakio	Kinangop	UH3
336	Geta	Geta	Kipipiri	UH2

Source of column 5: Jaetzold and Schmidt, 1983
Note: the cluster numbers (first column) correspond with the CBS classification.

Throughout the presentation and analysis a distinction is made between the UH1 and UH2 zones on the one hand, and the UH3 zone on the other. Since the different agro-ecological circumstances influence household opportunities and strategies, an analysis per zone leads to more reliable averages and conclusions. The UH1 and UH2 zones are treated as one, as the former is rather small, and the differences between them are only minor compared to the UH3 zone. Apart from zone-specific figures, totals for all surveyed zones (the horticultural zones as we call them) are presented in each table. [28]

[28] The relative sizes of the zonal sub-samples correspond with the relative number of households in the different zones. The sub-samples comprise 150 (UH1+2) and 90 (UH3) households, whereas 63% and 37%, respectively, of the households in the horticultural zones live in those areas (see Appendix 1).

2. Household characteristics

The present chapter deals with the characteristics of households in the horticultural zones. Some general information is presented after which the various farm and off-farm activities are explained.

2.1. General characteristics

Almost all farmers in Nyandarua are settlers who were allocated farms after Kenya attained independence. The size of the allocated holdings was related to the number of arable equivalents that was considered necessary to feed a household. The original holding size of settlers at Kahuru Sub-location in the UH3 zone, for instance, was 40 acres, while at Sabugo and Melangine Sub-locations in the UH2 zone it was 20 acres. The households in the former zone had to cope with lower soil fertility, while waterlogging was a big constraint on agricultural production. Allocated plots were smallest at more recent settlement schemes, like the ones along the upper slopes of the Aberdares at Geta Location (4 acres). This cannot only be explained in terms of arable equivalents but is also due to changing ideas about necessary farm size during the last decades.

Since the arrival of settlers, the land has been continually sub-divided into smaller units due to the principle of equal inheritance by all sons, and to the sale of pieces of land to newcomers. As a consequence, in 1990 the average holdings were half or less the original size, e.g. 22 acres at Kahuru-Muruaki, 10 acres at Sabugo and 8 acres at Melangine Sub-

locations (Appendix 5). At Geta, the already small holdings diminished to 3.6 acres in less than 20 years.[29]

The size of the households was larger in the UH3 zone than in the UH1+2 zone, in terms of both residents and part-time residents (Table 5). The latter were normally children who attended boarding schools and household members with jobs elsewhere. By far most of the households were male-headed (83%). Almost all the others were headed by a widow, with the exception of a few households where the wife and husband were separated or divorced, and the latter had left.[30] Polygamy was not widespread in the horticultural zones (8% of the households[31]). The level of education of the heads of households was found to be on average a few classes of primary school or adult literacy classes. Only a small minority of the household received education beyond the primary level (Appendix 5).

Table 5. Average holding and household size by zone, 1990

	UH1+2 zone (n=150)	*UH3 zone (n=90)*	*total (n=240)*
size of the holding (acres)	7.5	16.4	10.8
no of residents	6.0	7.2	6.4
no of part-time residents	0.7	2.2	1.3
total no of household members	6.7	9.4	7.7

See Appendix 5

2.2. Farming activities

Almost all households in the horticultural zones grew vegetables, with the exception of a few widowed elderly people who were no longer able to cultivate the land, and a couple of young teachers from elsewhere who did not have enough money yet to rent a plot.[32]

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[29] The average size was somewhat above 4 acres at the start of the scheme, because some owners had sold their property to other settlers immediately after receiving the land.

[30] A household where the husband was absent because of employment elsewhere, was still regarded as a male-headed household, although in such cases it was female-managed. Our definition was narrower than the one used by the CBS, which came to 39% female headed households for Nyandarua in 1981/82 (CBS, 1988).

[31] This figure is about the same as found by a survey of Hoorweg, et al among Kikuyus in Murang'a District. They found polygamy among 6 to 9% of the households depending on the location (Hoorweg, et al, 1983).

[32] During the survey, households were only questioned about the vegetables they grew on specific plots, including the kitchen garden. Plants which grew scattered throughout the compound were not included (e.g. kales and spring onions).

The high vegetable production was partly caused by potatoes, which serve as staple food in contrast to other vegetables. With the exception of potatoes, the percentage of households cultivating vegetables remained at the same level in the UH3 zone, but was considerably smaller in the UH1+2 zone (Table 6).

Over 85% of the households cultivating vegetables in both zones sold part of the harvest (Table 6). This applied both to potatoes, and to all the other vegetables together.[33] In the case of fruits the situation differed, because while the majority of the farmers possessed trees, only a minority sold the fruits. This illustrates the poor sales opportunities, as discussed in section 1.3. More farmers in the UH1+2 zone were able to sell fruits, especially in Sabugo, Melangine and Geta locations (Appendix 6). The first two areas on the upper slopes of the Bahati escarpment are served by a tarmac road which gives access to the fresh market in Nakuru. In the case of Geta, the most plausible explanation is the early start of the harvesting season (December) before the Nairobi market is flooded by temperate fruits from Kiambu in January. Accessibility of Geta is not a problem in December, in contrast with the second and third quarters of the year.

Table 6. Households cultivating and selling agricultural commodities by zone, 1990 (%)

	UH1+2 zone (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	growers	*growers selling*	*growers*	*growers selling*	*growers*	*growers selling*
all vegetables	96	92	100	94	98	93
- potatoes	92	86	98	93	94	88
- other vegetables	61	87	90	90	72	88
fruits	79	37	72	6	76	25
pyrethrum	19	58	18	78	19	63
cut-flowers	1	100	0	0	0	0

See Appendix 6

Two agricultural crops were grown exclusively for selling purposes: cut-flowers and pyrethrum. Cut-flowers, however, were cultivated by one farmer in the sample only. It shows the rareness of this kind of enterprise within the district in 1990. Pyrethrum was grown by a minority of the farmers in both agro-ecological zones. Although the commodity is grown for the sole purpose of selling the flowers, Table 6 shows a difference between the percentage of farmers growing and selling the crop. The remaining

[33] According to the outline of the research two categories of households would be compared: namely those who sold horticultural commodities and those who did not (Dijkstra & Magori, 1991). However, the limited size of the latter group rendered such a comparison useless.

farmers had just planted pyrethrum at the time of the survey, because their pyrethrum plants had been destroyed by floods during the previous year.

Cereals are not mentioned in Table 6 because they were grown on a very limited scale in the horticultural zones, mainly as cattle-fodder. Oats were planted for this purpose in the UH1+2 zone, and maize in all zones. The latter crop took eight to fourteen months to mature, but was normally harvested before reaching that stage. In case of land scarcity farmers sometimes inter-cropped maize with, for instance, cabbage.

2.3. Livestock

Livestock is of considerable importance to the economic welfare of Nyandarua District. Cows and sheep were kept by the majority of the households in the sample, not only as insurance against financial calamities, but also as a source of cash income. The latter was especially true in the case of cows. Almost all of them were graded or up-graded, with only a very small percentage of the households keeping traditional breeds (Table 7).[34] The animals were economic investments rather than means to accumulate capital, as is shown by the high percentage of households selling milk. Three out of four households that kept cows in 1990 sold milk to the Kenya Cooperative Creameries (KCC). Local sales took place only sporadically, because most of the households were self-sufficient with regard to milk.[35]

Table 7. Livestock by zone, 1990

	UH1+2 zone (n=150)	*UH3 zone (n=90)*	*total (n=240)*
households with (up) graded cows (%)	77	96	84
average no of (up) graded cows per owner*	2.6	3.3	2.9
households with cows selling milk to the KCC (%)	68	81	73
households with cows selling milk locally (%)	8	0	5
households with traditional cows (%)	0	2	1
households with sheep (%)	62	61	62
average no of sheep per owner*	6.8	8.0	7.2
households with sheep selling wool (%)	48	31	42

See Appendix 7
* mature animals only.

[34] An up-graded cow is defined as a cross-breed of a graded cow, like Frisian Holstein, and a traditional cow, like Zebu or Boran.
[35] At the time of writing of the report the KCC had lost its monopoly on milk buying. Farmers in Kinangop division also sold their milk to private traders in 1992.

The average number of cows per household was larger in the UH3 zone than in the UH1+2 zone, as was the percentage of households selling milk (Table 7). Livestock was more important in the former zone, most probably because of the unreliability of rainfall which made agricultural activities more hazardous, and because larger holdings allow larger herds. Most of the farmers employed an open grazing system instead of zero-grazing.

Cows supply not only milk, but also meat. Graded and up-graded cows, however, were only sold to be slaughtered when they had aged. Younger lactating cows were sold only in cases of urgent need for money, like a funeral. Farmers might sell their heifers if they did not want to expand their herd, but this was rare. On the other hand, bull calves were almost always sold at the age of one or two years, after they had been fattened. Besides producing milk and meat, cows were an important source of manure for improving the fertility of the soil and boosting vegetable production.

In general, sheep and goats are, more often than graded cows, kept as a kind of insurance. Approximately 60% of the farmers in both zones kept sheep, whereas goats were almost absent because of climatic conditions. The sheep might be kept for the sale of wool, although this was more common in the UH1+2 zone than in the UH3 zone (Table 7).

2.4. Off-farm employment

With diminishing farm holdings and improving educational levels, members of households are looking more and more for off-farm employment to supplement the income from farming activities. Within the horticultural zones of Nyandarua, over 40% of the households counted at least one member who was involved in some kind of off-farm employment.

The most common option was to be permanently employed, that is by the Kenyan Government or a private company (Table 8). Besides, the informal sector offered a wide range of job opportunities, of which self-employment (shopkeeping, food preparation, etc.) and trading (collecting, wholesaling, retailing, etc.) was the most common in Nyandarua. Casual work (usually agricultural labour) was not mentioned by many households. This is somewhat misleading, however, for of two reasons. First, people

who did paid farm work for some days when their own farm needed less attention, did not regard themselves as agricultural labourers. Second, farmers might help each other with farming activities in exchange for a good meal and return of labour. Payment in kind made it a friendly turn rather than a job.[36] Therefore, the casual jobs mentioned in Table 8 were mainly related to government projects like up-grading of roads.

Table 8. Off-farm employment by zone, 1990

	UH1+2 zone (n=150)	*UH3 zone (n=90)*	*total (n=240)*
households with off-farm income (%)	40	51	44
average no of jobs per hh in case of off-farm income	1	1	1
average no of months per year employed per job	11	11	11
type of employment (%):			
- permanent	53	63	57
-casual	7	0	4
-self-employed	26	17	23
-trading	14	15	14
-domestic labour	0	5	2
place of work (%):			
-in the neighbourhood	37	8	26
-elsewhere	63	92	74

See Appendix 8
notes: the neighbourhood refers to the village or its direct vicinity that can be reached on foot; hh=household

Table 8 shows that more households in the UH3 zone than in the UH1+2 zone were involved in off-farm employment. More often those jobs were situated elsewhere, in accordance with the larger number of part-time residents in the zone. A larger proportion of the jobs in the UH1+2 zone were nearby due to the proximity of divisional headquarters to the Njabini cluster, and the availability of forestry work around Geta, Melangine and Sabugo.

[36] It has to be noted that rotating labour groups are becoming less common nowadays.

3. Household income

3.1. Introduction

This chapter deals with the composition of household income in the horticultural zones. A distinction is made between farm income, land income and off-farm income.[37] Land income is treated as a separate category because renting out land is not regarded as an agricultural activity. Off-farm income concerns all activities outside the own farm. This not only includes wages earned by employees, but also revenues obtained through trading, shopkeeping, food preparation, liquor brewing, shoe cleaning, casual farm labour, etc.

Apart from the above mentioned sub-categories, two more distinctions will be made, namely gross income versus net income, and total income versus cash income.[38] Both are of special importance in case of farm activities. Gross farm income concerns the total value of farm output against selling prices (including agricultural commodities, livestock and livestock products), whereas net farm income is calculated by deducting the total farm costs from the gross farm income.[39] In respect of land, gross and net income are normally equal because of absence of cost. Net off-farm income has to be calculated by deducting possible cost of transportation and lodging from the remunerations.

Total versus cash income is of special importance in respect of farm activities. The cash component of the farm income consists of those commodities, animals and livestock

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[37] A household is defined as a group of people who reside together under one roof or under several roofs within a single compound, who are answerable to the same head (which means that they are kin), and share a common source of income. A similar definition is used by the Central Bureau of Statistics of Kenya.

[38] See also FAO (1980) and MOA (1989a).

[39] Farm output is valued against selling prices because Nyandarua is a surplus area as far as the produced commodities are concerned. If the district had been a deficit area, the output would have to be valued against buying prices (Levin, 1991).

products that have been sold by the farmer. The remaining non-cash income consists of household consumption of vegetables, fruits, milk and meat, and produce set aside as seed. In case of livestock the non-cash component also includes the value increase of the herd.[40]

The concept of total versus cash income is normally combined with the distinction between gross and net income in order to calculate net income and net cash income. Appendix 9 explains the various definitions in more detail.

3.2. Household (cash) income

According to the farm survey, the average net household income in the horticultural zones was over KSh 38,000 in 1990, of which KSh 29,000 were cash revenues (Table 9).[41] Vegetables and livestock were the most important sources, followed by off-farm employment. Incomes out of fruits, pyrethrum and renting out land were on average small.

Table 9. Average net income and cash income by zone, 1990 (KSh/household)

	UH1+2 zones (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	*total**	*cash*	*total**	*cash*	*total**	*cash*
net vegetable income	24,009	18,308	8,243	5,398	18,097	13,467
net fruit income	434	434	32	32	283	283
net pyrethrum income	249	249	1,014	1,014	536	536
net livestock income	11,200	6,753	16,455	10,267	13,170	8,070
net farm income	35,892	25,744	25,744	16,711	32,086	22,356
net land income	23	23	160	160	75	75
net off-farm income	6,568	6,568	6,319	6,319	6,475	6,475
net household income	42,483	32,335	32,223	23,190	38,636	28,906

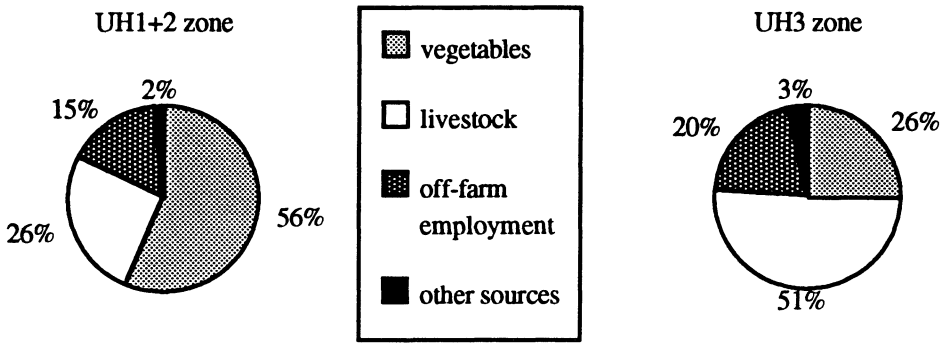
See Appendices 11 and 12
* includes cash and non-cash income

The relative importance of vegetables and livestock differed from one zone to the other. Vegetable production generated more than twice as much income as livestock in the UH1+2 zone, whereas the opposite was true in the UH3 zone (Figure 2). The explanation has already been given in previous sections: first, although almost all households in both

[40] New-born calves increase the value of the herd as long as they are not sold. Value increases also take place when heifers become lactating cows, or cows become better milkers. All are included in the household income, but not in the household cash income.
[41] Appendix 10 summarizes the calculation method for the various types of income.

zones grew vegetables, yields were lower in the UH3 zone due to less reliable rainfall and lower fertility; second, more households in the UH3 zone reared cows, and the number of cows per owner was larger.

Figure 2. Composition of average net household income by zone, 1990



Within the UH1+2 zone, a clear distinction existed between the more recent settlements on the upper slopes of the Aberdares and others. The smaller holdings in those settlements affected the agricultural incomes of the households, as is shown by the results for Geta location (Table 10).[42] Household incomes were about half the average of the total UH1+2 zone, although incomes out of off-farm employment did not differ much from other areas.

Table 10. Average holding and income of sub-locations in the UH1+2 zone, 1990

	Sabugo (n=30)	*Melangine (n=30)*	*Tulaga (n=30)*	*Njabini (n=30)*	*Geta (n=30)*	*Total (n=150)*
size holding (acres)	10.1	7.9	9.1	6.8	3.6	7.5
net vegetable inc. (KSh/hh)	27,276	27,761	21,715	32,037	11,254	24,009
net livestock inc. (KSh/hh)	13,631	19,333	8,504	8,104	6,428	11,200
net off-farm inc. (KSh/hh)	8,080	9,113	4,122	5,607	5,919	6,568
net household inc. (KSh/hh)	50,509	56,977	34,360	45,861	24,708	42,483

See Appendices 5 and 11
Abbreviations: hh=household, inc=income

In Table 9, total income and cash income were equal in respect of land and off-farm employment because off-farm activities and renting out land generated cash revenues

[42] The small average size of the holdings would not have to curtail agricultural activities if renting land was easy. However, all holdings at Geta were small so that only a few households rented out land (see Appendix 13).

only.[43] The same held for pyrethrum and fruits. Income and cash income out of pyrethrum were equal because households did not use the flowers themselves. Income and cash income out of fruits were considered to be equal, because sales opportunities were limited, and fruits that were already harvested but could not be sold had to be fed to cattle or left to rot. Although part of the unsold fruits might be eaten by household members, especially children, they were not considered important.

The cash component in vegetables and livestock made up about three-quarters and three-fifths of the total income respectively. In absolute terms, households in the UH1+2 zone made more money out of vegetables while those in the UH3 zone received more cash through their livestock activities. Altogether, households were considerably poorer in the UH3 zone than in the UH1+2 zone, in terms of both wealth (total household income) and welfare (household cash income).[44]

3.3. The costs of poor infrastructure

Cash incomes, as discussed in the previous sub-section, were calculated on the basis of sold quantities and expected further sales of the crop still in the field. During 1990, these expectations normally came true, but this is not always the case, especially when roads are blocked for considerable periods because of flooding. Under such circumstances, farmers have no other option than to feed perishables like milk and harvested vegetables to the cattle or to let them go bad.[45] Once the situation has improved again, they may still not be able to seli their vegetables because of an abundant supply of delayed-harvest produce.

According to extension officers, losses due to impassible roads were normally higher for vegetables than for milk, for two reasons. First, the cooperatives collecting the milk often used tractors, which were better suited to flooded roads than the trucks of horticultural middlemen. Second, if necessary, farmers carried their milk for 10 kilometres or more on

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[43] In theory, households might receive income out of off-farm employment and land in kind, but this was not the case in our sample. The only exceptions were meals provided to farm labourers, but they were excluded from the calculations.

[44] According to the FAO, the total household net income is a measure of wealth and, in case of self-sufficient food production, the total household net cash income is a measure of welfare (FAO, 1980).

[45] Although fruits were also fed to the cattle, this was not because of an accessibility problem (fruits are harvested between December and March, which is a relatively dry period of the year), but because of lack of demand in the urban markets (see section 1.3).

their heads, in order to reach a place were it could be collected. This was feasible with 7 litres of milk, but not with 30 bags of potatoes each weighing 120 kilogrammes.[46]

It is difficult to quantify the negative affects of blocked roads on household cash incomes. Of the farmers who sold milk 11% complained about irregular milk collection, but actual losses were not measured. In case of vegetables, bad roads not only hampered sales opportunities, but also affected off-farm prices whenever middlemen were present because of high transport costs to the urban centres. The smaller number of middlemen during periods of excessive rains also increased their bargaining power.

Let us examine the situation of a blocked Njabini-Kipipiri-Ol Kalou road during the month of August. This is not a theoretical option, at least up to 1990. It would affect cash incomes in three of the surveyed clusters, namely Tulaga and Geta in the UH1+2 zone, and Kahuru/Muruaki in the UH3 zone.

Although harvesting is done throughout most of the year, August is a peak period in which approximately 20% of the total annual harvest is brought in. The loss in terms of cash, as caused by the blocked road, would however be higher because inputs would have been paid regardless of sales results. The loss of cash revenues out of milk sales would be approximately 10% if none of the milk reached the cooperative.[47] We assume however that half of the milk would reach its destination through a combination of

Table 11. Average actual cash income and cash income in case of a blocked Njabini-Kipipiri-Ol'Kalou road, 1990 (3 clusters) *

	Tulaga (UH1+2)		*Geta (UH1+2)*		*Kahuru (UH3)*	
	actual 1990 (KSh)	*blocked road (%)*	*actual 1990 (KSh)*	*blocked road (%)*	*actual 1990 (KSh)*	*blocked road (%)*
net vegetable cash income/hh	15,793	75	10,056	76	3,176	63
net livestock cash income/hh	3,899	96	2,260	96	9,720	95
net farm cash income/hh	19,704	79	13,377	82	14,386	89

See Appendix 14
Note: hh=household
* It is assumed that the road is blocked during August, affecting 20% of the vegetable sales and 5% of the milk sales.

[46] The average daily milk sales was about 7 litres per household with (up)graded cows, and the average potato harvest per plot was about 30 bags. Sometimes donkeys were used for local transportation, but they had a limited carrying capacity, and were scarce.
[47] The cows lactate for approximately 10 months a year.

carrying on the head and tractor services provided by the cooperative society.[48] Calculations reveal that the net farm cash incomes in the affected clusters would be 11 to 21% lower, depending on the relative importance of vegetables and livestock (Table 11).

3.4. The effects of rising prices of agricultural inputs

The average incomes as found by our farm survey were at least moderate according to Kenyan standards.[49] Since 1990, however, incomes have declined due to rising input costs. In the present section, we will estimate the consequent changes in vegetable and household incomes, while Chapter 5 will deal with changing profitability of the individual horticultural crops.

Table 12 shows the changes in vegetable and household income, when calculated against 1992 input prices.[50] The calculations are based on three assumptions. First, that the higher input costs did not affect the cropping pattern. This is not completely true, because some farmers decided to put less effort into horticulture when profits declined.[51] Therefore, our recalculated vegetable incomes are on the higher side.

Table 12. Average net income by zone against 1990 and 1992 input prices (KSh/household)

	UH1+2 zones (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	actual inc.	*1992 input prices*	*actual inc.*	*1992 input prices*	*actual inc.*	*1992 input prices*
net vegetable income	24,009	20,891 (87%)	8,243	4,534 (55%)	18,097	14,757 (82%)
net household income	42,483	39,365 (93%)	32,223	28,514 (88%)	38,636	35,296 (91%)

See Appendix 15

The second assumption is that farm-gate prices for the horticultural commodities did not change. Selling price increases might be expected between 1990 and 1992, because of a smaller supply. However, a drop in demand for vegetables, due to decreasing real urban incomes, counterbalanced the changes in supply. Consequently, farm-gate prices

[48] It is assumed that farmers who cultivate pyrethrum are able to store the harvested flowers until the roads are passable again. Therefore the revenues out of pyrethrum would not be affected.
[49] The minimum government wage was KSh 1500 per month in 1990, that is KSh 18,000 per annum.
[50] See Appendix 10, section 9, for the calculation method of the net vegetable income against 1992 prices.
[51] According to the district extension officers, these farmers focused their attention to a larger extent on livestock production and cultivation of maize for home consumption, especially on the lower slopes of the Aberdares (the UH3 zone).

remained roughly at the same level, as was confirmed by farmers during interviews in 1992.

The last assumption is that other sources of income remained constant between 1990 and 1992. This is plausible because farmers do not use many inputs in case of pyrethrum and fruits (apart from family labour), while prices for milk and off-farm wages did not change much over the two-year period.

According to Table 12, rising input costs affected incomes to a larger extent in the UH3 zone than in the UH1+2 zone. The average vegetable income in the former zone was almost halved against a decline of one seventh in the latter. The effects were less severe in the UH1+2 zone due to higher yields. It can be concluded that increasing input costs further widened the wealth gap between the two zones.

Table 13. Composition of average net income by zone against 1990 and 1992 input prices (%/household)

	UH1+2 zones (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	actual inc.	*1992 input prices*	*actual inc.*	*1992 input prices*	*actual inc.*	*1992 input prices*
net vegetable income	56	53	26	16	47	42
net livestock income	26	28	51	58	34	37
net off-farm income	15	17	20	22	17	18
other sources of income	2	2	3	4	2	2
net household income	100	101	100	100	100	99

See Appendices 11 and 15

With regard to the relative importance of the various income sources, vegetables remained the major source of income in the UH1+2 zone, while falling back to the third place in the UH3 zone (Table 13). Livestock gained further ground as the most important source of household income in the latter zone. It explains the dedication of farmers in the UH3 zone to this enterprise. According to extension workers, many farmers in the area prefer to feed cabbages to their cattle rather than selling it to the middlemen when the margins decline.

4. Horticultural production and income

The present chapter looks into the cultivation practices of individual horticultural crops, and the relative importance of own consumption versus sales of the various commodities. The composition of incomes from vegetables and fruits in the horticultural zones will be analyzed.

4.1. Vegetable cultivation

Types of vegetables

The potato is the major vegetable in Nyandarua, as we already saw in sections 1.3 and 2.2. Two other common vegetables are green peas and cabbage.[52] Their importance differs from one zone to another: in 1990 they were cultivated by twice as many households in the UH3 zone as in the UH1+2 zone (Table 14). In the latter zone more

Table 14. Households cultivating and selling vegetables by zone, 1990 (%)

	UH1+2 zone (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	growers	*growers selling*	*growers*	*growers selling*	*growers*	*growers selling*
potatoes	92	86	98	93	94	88
green peas	37	84	76	88	52	87
cabbages	31	84	65	83	44	84
spring onions	19	100	2	0	13	92
kale	7	71	2	0	5	60
carrots	4	50	2	100	3	67
bulb onions	0	0	1	100	0	0

See Appendix 16

[52] Green peas are also called garden peas. They are normally shelled and dried before being stored for own consumption, but sold while still fresh and unshelled.

households grew potatoes only.[53] In both zones, over three-quarters of the households that cultivated green peas and cabbages also sold part of the harvest.

The fourth vegetable of importance is spring onions. Its commercial production is, however, mainly restricted to one specific location in the UH1+2 zone, namely Geta, where farmers cultivated them for selling purposes on separate plots.[54] Elsewhere, farmers normally grew a few plants for own consumption on the edge of vegetable plots. These farmers were not included in the table.

Kale, carrots and bulb onions were of minor importance in Nyandarua. In the case of bulb onions the reason was most obvious: sub-optimal temperatures and too much rain.[55] The minor importance of carrots was explained in section 1.3. This leaves kale, which was a successful cash crop for Nyandarua farmers in the 1970s, when 40% of the kale supply in Nairobi wholesale market originated from the district (Ngeno, 1978). Since then the production of kale in Nyandarua has declined, due to competition from Kiambu.

Number of crop cycles

The Nyandarua farmers grow two to three successive crops a year. The number of crop cycles depends on several variables - above all on the growth period for each crop. Of the early maturing varieties potatoes take 3 months and cabbages take 2.5 to 3 months, whereas late maturing varieties take 4 and 3.5 to 4 months respectively (MOA, 1989a). Farmers may decide to plant the early maturing varieties in situations of less reliable rainfall like in the UH3 zone. The choice for a variety is, however, not only related to the length of the growth period, but also to consumer preferences regarding taste, storage quality, and in case of cabbages, the size of the head. The Copenhagen variety of cabbage, for instance, is getting more popular at the expense of Drumhead because of its quick growth, sweetness and small size of the head. It is also preferred to Sugar loaf because of its better storage quality. Another cabbage variety that is getting popular because of its keeping quality, especially among institutional buyers, is Gloria, but the seeds are expensive.

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[53] In the UH1+2 zone 36% of the households grew potatoes only in 1990, against 10% in the UH3 zone.
[54] Spring onions are also called shallots.
[55] Temperatures below 15 degrees are unsuitable for the crop, whereas it needs a dry period for the ripening of the bulbs (MOA, 1989a).

The number of crop cycles also depends on whether relay cropping is applied. This is a kind of intercropping whereby for instance cabbage seedlings are planted between the rows of potatoes when the latter start to lose their leaves and have been weeded. Harvesting of the potatoes thus coincides with weeding between the cabbage crops. Through such a system, which also saves labour, more crop cycles fit into the same period but the yields per crop are lower than for monoculture.

So far, we have dealt with rainfed production. Another way to increase the number of crop cycles is through irrigation. Farmers who use irrigation are able to harvest the whole year round. They are, however, a small group, because Nyandarua does not have many rivers that can be used for this purpose.

Agricultural calender

This brings us to the agricultural calender of rainfed horticulture in the horticultural zones. Land preparation, which normally includes ploughing and harrowing, starts in January. The subsequent sowing starts in the UH1+2 zone in February and in the UH3 zone in March. Table 15 shows the sequence of farm activities in cases of two and three crop cycles. Activities such as spraying, weeding, and ridging (in case of potatoes) are carried out between planting and harvesting. The time of harvesting depends on the variety, as we have seen. Potatoes are always harvested in one go, whereas peas have to be picked during successive rounds taking 4 to 6 weeks in all. Cabbages are either harvested at once, or during a few rounds, depending on harvesting and selling arrangements with middlemen.

Table 15. Agricultural calender for vegetables in Nyandarua District

Crop	*Month*												
	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*J*
2 crops	L	L/S	S	S	H	H	H/S	H/S	S	H	H	H	H
3 crops													
-potatoes only	L	L/S	S		H/S	H/S		H/S	H/S		H	H	H
-crop rotation:													
1st crop peas	L	S	S		H	H							
2nd crop potatoes							S	S			H	H	
3rd crop cabbage								S	S/T	T	H	H	H

Legend: L= Land preparation, S=sowing, T= transplanting, H= Harvesting

Farmers only plough the land entirely prior to sowing the first crop. The second crop is normally planted immediately after harvesting the first one, whereby land preparation is carried out while harvesting. If both crops are potatoes, the smaller tubers are often left in the field during harvesting to serve as new seeds. It will be clear that such practices increase the risk of seed-borne diseases. Crop rotation can be undertaken as relay cropping, as we explained earlier. Table 15 shows crop rotation with relay cropping of green peas, potatoes and cabbages. The cabbages are raised in a nursery and transplanted after four to six weeks, while the potatoes and peas are sown directly in the field.

Table 15 shows that harvesting rainfed horticulture in the district is possible during three-quarters of the year. Peak periods occur in July/August and from mid-November to mid-January. Individual farmers try to plan production so that total labour requirements are spread throughout the year. They subdivide the holding into manageable plots, and then phase planting to avoid labour constraints during weeding and harvesting. Harvesting normally ends in January of the following year. If farmers continue to cultivate vegetables on the same plot, the land is not always ploughed again. It will be clear that such an intensified use of plots affects the fertility of the soil, especially if fertilizers are applied insufficiently. Soil-borne diseases also become rampant under such circumstances.

4.2. Vegetable production and consumption

Potatoes were cultivated by almost all households in the horticultural zones, as we saw in the previous sections. The importance of the commodity is shown once again when we compare annual harvests. Households produced about three times as many bags of potatoes as cabbages, with cabbages being the second important vegetable (Table 16). The other vegetables were of minor importance in terms of harvested bags.

The UH1+2 zone has a higher production per household of all vegetables with the exception of green peas. Zonal differences were the most extreme in the case of potatoes, and almost absent in the case of cabbages. The relatively high production of spring onions in the UH1+2 zone originated almost completely from Geta location where farmers produced an average of 27 bags of this commodity per year. Altogether the production was more diversified in the UH3 zone.

Table 16. Average quantities of vegetables consumed, sold and harvested by zone, 1990 (bags/year/household)

	UH1+2 zones (n=150)			*UH3 zone (n=90)*			*total (n=240)*		
	cons	*sold*	*harv*	*cons*	*sold*	*harv*	*cons*	*sold*	*harv*
potatoes*	22	94	128	6	37	54	16	72	100
cabbages	5	34	39	11	25	36	7	30	37
spring onions	0	6	6	0	0	0	0	4	4
green peas	1	3	4	2	5	7	1	4	5
kale	0	3	3	0	0	0	0	2	2
carrots	0	1	1	0	1	1	0	1	1
bulb onions	0	0	0	0	0	0	0	0	0

See Appendices 17 and 18
Note: cons= consumed, harv= harvested
*In case of potatoes consumption and sales do not add up to harvest because part is used as seed for the next crop.

Table 16 also shows the destination of the various harvested commodities. By far the largest part was sold, which means that vegetables were primarily grown for commercial purposes. Home consumption of potatoes was much lower in the UH3 zone than in the UH1+2 zone, which suggests a more prominent role of maize flour (*ugali*) as part of the diet. On the other hand, households in the UH3 zone consumed considerably more cabbages and peas, although this was, at least partly, related to the larger number of residents in the households.

4.3. Vegetable (cash) income

The net income from vegetables is determined by harvesting quantities, selling prices and cultivation costs. The first factor was discussed in the previous section whereas the other two will be analyzed in Chapter 5. For now, we will look at the composition of the average net vegetable income and cash income at household level. Potatoes, cabbages, spring onions and green peas are the four main contributors (Table 17). Potatoes were even more important in terms of economic value than physical units. While on average two-thirds of the harvested bags were potatoes, they represent three-quarters of the net vegetable income and net vegetable cash income (Table 18). On the other hand, one quarter of the harvested bags were cabbages, while they accounted for only 15% of the net average vegetable income and cash income. This is the result of the smaller net margin per bag of cabbages than potatoes, as we will see in Chapter 5.

Table 17. Average net income and cash income out of vegetables by zone, 1990 (KSh/household)

	UH1+2 zones (n=150)		*UH3 zone (n=90)*		*total n=240)*	
	*total**	*cash*	*total**	*cash*	*total**	*cash*
potatoes	18,720	13,813	5,209	3,773	13,655	10,048
cabbages	2,966	2,385	2,419	1,273	2,761	1,968
spring onions	1,738	1,702	0	0	1,086	1,064
green peas	422	292	507	257	454	279
kale	111	76	9	-3	7	46
carrots	52	41	66	66	57	50
bulb onions	0	0	33	33	12	12
total all vegetables	24,009	18,308	8,243	5,398	18,097	13,467

See Appendices 19 and 20
* includes cash and non-cash income

Besides potatoes, spring onions offered good returns. The commodity was twice as important in terms of income as in terms of physical units, which, again, can be explained by a high net margin per bag. This, however, resulted from specific circumstances in Geta location. Spring onions were even more important in terms of cash than of total income, which was due to the absence of own consumption in contrast with the other vegetables (see section 4.2).

Green peas were the fourth vegetable to contribute to the net vegetable income and cash income. Its importance in terms of value and bags did not differ to a large extent. The other vegetables, that is kale, carrots and bulb onions, did not count in terms of money. This was caused by a relatively small margin per bag (kale) and the limited number of farmers producing the crop (carrots, bulb onions).

Table 18. Composition of average vegetable harvest and vegetable (cash) income by zone, 1990 (%/household)

	UH1+2 zones (n=150)			*UH3 zone (n=90)*			*total (n=240)*		
	harv. bags	*total inc.*	*cash inc.*	*harv. bags*	*total inc.*	*cash inc.*	*harv. bags*	*total inc.*	*cash inc.*
potatoes	71	78	75	55	63	70	67	75	75
cabbages	22	12	13	37	29	24	25	15	15
spring onions	3	7	9	0	0	0	3	6	8
green peas	2	2	2	7	6	5	3	3	2
kale	2	0	0	0	0	0	1	0	0
carrots	0	0	0	1	1	1	1	0	0
bulb onions	0	0	0	0	0	1	0	0	0
total all veg.	100	99	99	100	99	101	100	99	100

Based on Tables 16 and 17
Abbreviations: harv=harvested, inc=income, veg=vegetables

The relative insignificance of green peas, kale and carrots to the vegetable cash income in both the UH1+2 and UH3 zones, is another indication of the lop-sided character of horticultural production in Nyandarua District, not only in terms of output but also in terms of cash revenues. If potato cultivation were to collapse as a cash crop, because of either diseases or market forces, households might on average lose three-quarters of their cash revenues out of vegetables, or 35% of their total household cash income.[56] The consequences would be greater in the UH1+2 zone, where potatoes brought in 43% of the total household cash income in 1990, against 16% in the UH3 zone. Households in the latter zone would be affected to a lesser extent because of the somewhat larger contribution of other vegetables and more substantial revenues out of livestock.

4.4. Determinants of vegetable income

The previous section dealt with average household incomes from vegetables per zone, but within each zone differences exist at a lower level of aggregation, that can be subdivided into two groups. The first group of factors relates to characteristics of individual households, like the size of the holding, the size of the household labour force available for farm labour, whether male or female headed, and whether monogamous or polygamous. Each of these variables may determine decisions regarding vegetable production through availability of land and labour, and allocation of tasks within the household.

The second group of factors relates to the financial situation of the individual households, namely cash incomes out of other activities than vegetable cultivation. In the horticultural zones of Nyandarua those other activities can be off-farm employment, livestock, or pyrethrum cultivation. They may on the one hand influence investments in vegetable production through availability of funds, and on the other represent alternative allocations of scarce resources.

The afore mentioned factors are not crop-specific. When examining one vegetable crop-specific factors can be introduced, like the fertilizer applications per acre, and the average

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[56] This would, of course, only be the case in the short run, because households could switch to other vegetables in the long run. If diseases were to make potato cultivation completely impossible, not only would the cash revenues be affected but also the food supply to the household. Switching to other vegetables would not be a solution because cultivation of other staple crops (including maize) is almost impossible in the horticultural zones (especially the UH1 and UH2 zones).

size of the crop harvest per sub-location. The first is related to the intensity of production, which may influence the generated income through yields and cultivated acreages, and the second is related to the collection costs of middlemen who buy the vegetable. The traders may be willing to pay a better price in case of lower collection costs, boosting the income of the farmer.[57]

Structural equation modelling was carried out to ascertain which of all the above mentioned factors actually interact and influence the vegetable income of individual households in the horticultural zones of Nyandarua. The analysis focussed on potatoes in the UH1+2 zone, because potatoes are the most important commodity of the district and the UH1+2 zone is the biggest producer. The results of the analysis are shown in Figure 3, while the statistical method is explained in Appendix 21. The various interactions of factors are discussed one by one.

The gross potato income is decided by the size of the potato harvest and the selling price; multiplication of the latter two gives the gross potato income. Similarly, the size of the potato harvest is decided by the number of acres under potatoes and the yields per acre.[58] Acres, yields and selling price are then further analyzed. Acreage under potatoes is influenced by the income out of milk sales.[59] The latter factor was introduced in the course of the analysis because milk sales are a regularly source of money, unlike the sale of cattle, which is normally done on special occasions or during specific times of the year. Therefore, revenues out of milk sales are a better indicator for day-to-day money availability than total livestock cash income. The positive correlation between acreage under potatoes and milk sales suggests a capital constraint, whereby revenues out of milk sales generate funds that are needed to grow potatoes. Acreage under potatoes is also influenced by the fertilizer applications per acre. The negative correlation implies that farmers grow fewer acres of potatoes if fertilizer applications per acre are larger. This suggests that they opt either for more intensified production on fewer acres or for less intensified production on more or larger plots.[60]

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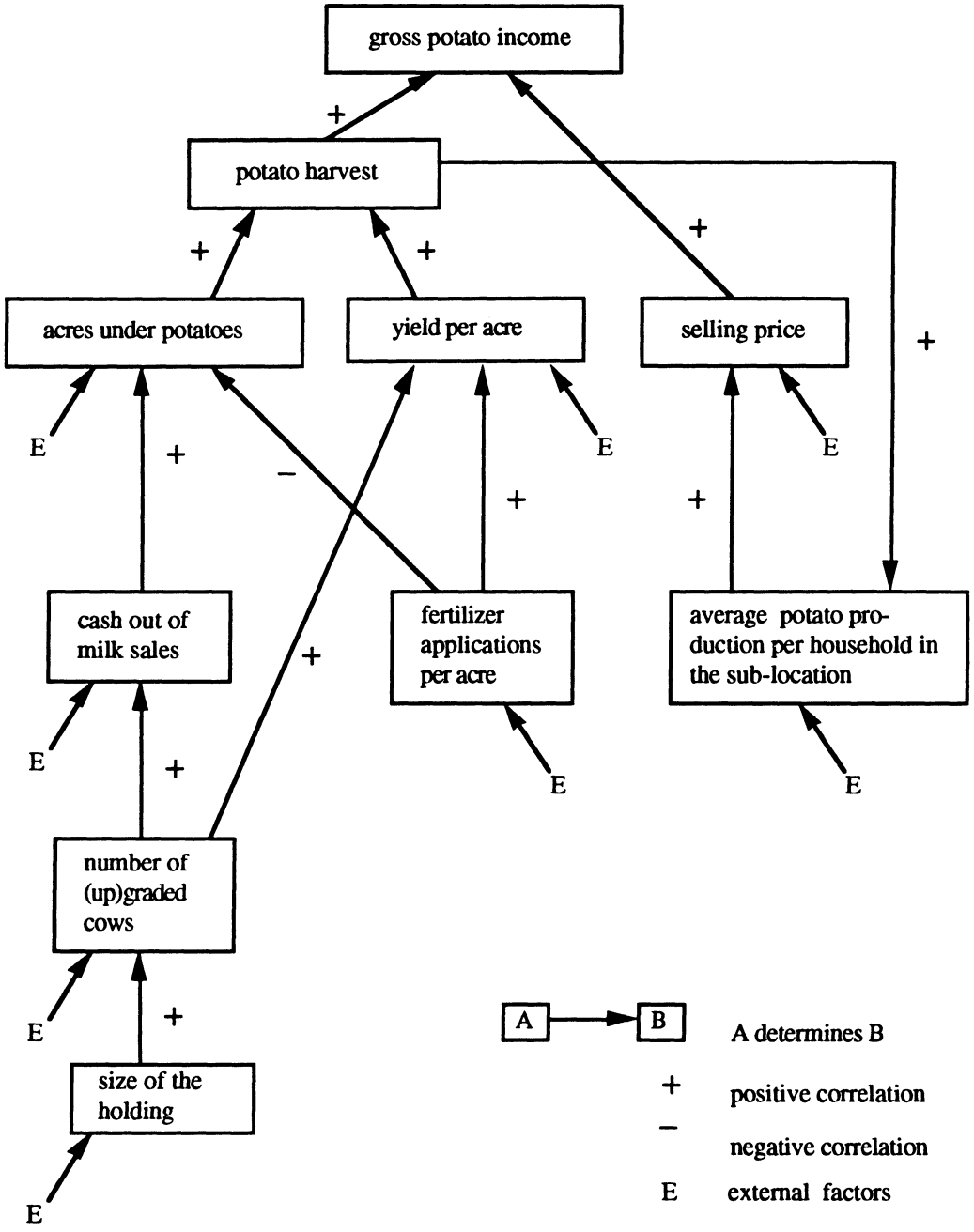
[57] Another possible factor is the distance to the nearest tarmac road, as indicator for the accessibility of the area. This variable has, however, a low discriminating value within our sub-sample because three out of the five clusters in the UH1+2 zone were situated near the tarmac road while the cluster with the lowest accessibility, that is Geta, was not part of the potato sub-sample.

[58] The variables were transformed into natural logarithms to get linear relations.

[59] It has to be noted that the analysis deals only with households selling at least some milk (see section 2.3) because of the transformation of the variables into natural logarithms.

[60] Another explanation could have been that farmers use limited quantities of fertilizer regardless of the acreage under potatoes, so that applications per acre decrease as the number of acres under potatoes increase. This is, however, not the case since a positive correlation exists between total fertilizer applications and total acreage under potatoes.

Figure 3. Causal diagram of gross potato income of households in the UH1+2 zone



Note: all variables have been transformed into natural logarithms
See Appendix 21

There is a positive correlation between the yields and the number of (up)graded cows. The latter variable was introduced in the course of the analysis together with milk sales. The relation between yields and (up)graded cows can be explained by the availability of cow dung to boost the growth of horticultural crops. The more cows a farmer has, the more dung he has available, which, according to the analysis, results in a higher vegetable income through higher yields. The number of (up)graded cows is influenced by the size of the holding, which suggests that households with more land kept more cattle because they have more space to graze the cows. The yields are also positively related to the fertilizer applications per acre, which was to be expected as bigger fertilizer gifts lead to higher yields.

So far, it can be concluded that cows are important motors of vegetable production, both directly by means of dung and indirectly through milk sales that generated cash which could be used to invest in vegetable cultivation. The interrelation between vegetable and livestock production is important from an extension point of view. It shows the need for an integrated approach.

The selling price of the potatoes is positively influenced by the average quantity of potatoes harvested per household in the location. It suggests that farmers benefit from concentration of supply. Traders are probably willing to pay higher farm-gate prices if they have to travel less far to get their trucks filled. This is understandable in view of savings on fuel cost and collection time. The average potato production per household in the sub-location is positively correlated with the potato harvest of the individual households. This suggests that farmers stimulate each other to grow a specific crop.

In sum, it can be said that potato production of individual households is influenced by various factors: 1) cash out of milk sales and number of (up)graded cows, affecting the size of the potato harvest through the acreage under potatoes and the yields per acre; 2) the fertilizer applications per acre, affecting the potato harvest through the same variables; and 3), the average potato production of households in the sub-location, affecting the gross potato income of these households through the selling price.[61]

[61] Factors without proved significance were the size of the household labour force, the sex of the household head and type of marriage, the income out of off-farm employment and pyrethrum production.

4.5. Fruit production

Plums are by far the most common type of fruit on the farm, followed by pears. Other temperate fruits, like peaches and apples, were only cultivated by a few farmers (Table 19). The prevalence of plum and to a lesser extent pear trees in the horticultural zones was the result of earlier promotion by jam factories, as we saw in section 1.3. Apple trees were rather new in the district, and only three out of the eight questioned farmers who had planted seedlings were able to harvest fruits already in 1990. All apple-tree owners in the UH1+2 zone lived in Geta location, so that 17% of the households in that area were involved in (future) apple production. Tree-tomatoes and loquats were only grown by one farmer each, which is understandable because the suitability of these trees to the upper highland zones is doubtful.

Table 19. Households with fruit trees and average number of trees per owner, 1990

	UH1+2 zone (n=150)		*UH3 zone (n=90)*		*total (n=240)*	
	% of house-holds	*average no of trees per tree owner*	*% of house-holds*	*average no of trees per tree owner*	*% of house-holds*	*average no of trees per tree owner*
Plums	76	29	69	17	73	24
Pears	34	15	36	14	35	15
Apples*	3	82	3	21	3	59
Peaches	1	6	0	0	0	0
Tree-tomatoes	1	2	0	0	0	0
Loquats	0	0	1	7	0	0

See Appendix 22
Note: Except for apples only full-grown trees were counted.

The range of fruit trees per owner was very wide concerning all major fruits, with a maximum of 216 full-grown plum trees, 100 full-grown pear trees and 320 apple trees. The latter extreme inflated the average number of apple trees in the UH1+2 zone as shown in Table 19, because of the limited number of farmers involved.

Fruit trees do not require much labour except for pruning and harvesting. Without annual pruning the yields will drop quickly, while a possible recovery will take some years. Harvesting requires labourers to climb the trees and pick the fruits.[62] Orchards may also need weeding, but farmers often graze their cattle under the trees for this purpose. Only larger farmers have orchards anyway, whereas the others have planted the trees on the borders of farm plots or around their house.

[62] It is better to pick the fruits than to gather them because dropped fruits tend to be riper, and hence more perishable.

Apple trees need some extra care to ensure a successful harvest. Under Kenyan climatic conditions they fall into dormancy around July and August, and need artificial bud-breaking in order to blossom (MOA, 1989a).[63] This can be done either by means of defoliation by hand or spraying with chemicals. Both methods need careful planning to produce effect. This makes apple production a more complicated kind of farm enterprise, which partly explains why so few farmers were as yet involved, although it is a profitable business. Another reason is the lack of rootstocks for sale to farmers wanting to start an apple orchard. Although the necessity of developing alternatives to plums and pears has been felt for over a decade, the Farmers' Training Centre (FTC) in Njabini only recently started to produce its first apple rootstocks. Until now, apple farmers have been producing their own planting material, which made high-yielding trees a matter of chance. Besides the shortage of rootstocks, the lack of guns to scare away the birds has been a problem in apple production.

4.6. Fruit (cash) income

The average fruit income was quite low in 1990, as we saw in section 3.2.[64] Therefore we will will look at its composition only briefly. Plums remained the most important fruit, although their preponderance was less in terms of revenues than in terms of numbers of trees. Almost three-quarters (72%) of the trees in the horticultural zone bore plums and one-fifth pears, while their contributions to the average fruit income were about 60% and 40% respectively (Table 20). This can be explained by the larger net margin for pears than

Table 20. Average net fruit (cash) income by zone, 1990

	UH1+2 zones (n=150)		*UH3 zone (n=90)*		*total n=240)*	
	KSh	*%*	*KSh*	*%*	*KSh*	*%*
plum	259	58	27	84	172	61
pear	168	39	5	16	107	38
apple	7	2	0	0	4	1
other	0	0	0	0	0	0
total all fruits	434	99	32	100	283	100

See Appendix 23

[63] In Kenya apples can be cultivated successfully between 1,800 m and about 2,800 m altitude only (MOA, 1989a). This includes the upper highland zones (UH1, UH2 and UH3) of Nyandarua.

[64] Fruit income and fruit cash income were defined as being equal in that section.

plums, mainly because of higher selling prices.[65] Apples contributed only 1% to the average fruit income, although their net margin was much higher than that of all other fruits. The reason for this low percentage was the small number of farmers with apple trees and the fact that most of the trees were still young (see section 4.5).

Although revenues out of plum and pear sales were on average higher in the UH1+2 zone than the UH3 zone, sales opportunities were restricted to a few locations on the upper slopes of the Bahati escarpment, because of the presence of a direct tarmac road to Nakuru, and in Geta location because of the early start of the harvest (see section 2.2). Households in the other locations received negligible incomes out of the temperate fruits, in both the UH1+2 and UH3 zones.

[65] The average net margins were KSh 17 per debe of plums, KSh 36 per debe of pears and KSh 10 per kilogramme of apples.

5 Costs and benefits of horticultural production

We will now focus on cost-benefit analyses of the most important horticultural commodities in the district, that is potatoes and cabbages. They accounted for 91% of the average net vegetable income in the horticultural zones, and 42% of the average household net income.[66] In addition to those two crops, spring onions will be discussed because of their major importance to farmers in Geta Location.

5.1. Costs of inputs

Like all farmers, cultivators of horticulture start the agricultural year with preparing the plots.[67] Proper land preparation gives a fine tilth and good soil inversion, which is very important for vegetable seeds. The majority of the farmers used manual labour to prepare the plots, but some switched to hired tractor services, especially for potatoes and cabbages (Table 21). Mechanical land preparation was most common for potatoes, which is understandable because tubers need better ploughing than brassicas, more so because the latter are transplanted. For spring onions, ploughing was done by means of hoes and *jembes*. This was not so much related to the crop as to the location, because Geta is quite

Table 21. Farmers using inputs by commodity, 1990 (%)

	potatoes (n=155)	*cabbages (n=27)*	*spring onions (n=16)*
tractor services for ploughing	39	29	0
tractor services for harrowing	10	7	0
certified seed	22	96	0
fertilizer	91	89	39
purchased mulch	2	0	0
pesticides/fungicides	62	41	0

source: farm survey

[66] See sections 3.2 and 4.3.
[67] Section 4.1 specifies the agricultural calender.

hilly and therefore less suitable for tractors.

After ploughing, and sometimes harrowing, farmers have to sow or plant. Cabbage seeds are normally sown in a seed bed, after which the seedlings are transplanted. Some farmers buy the seedlings from colleagues who specialize in germinating cabbage seed and selling the seedlings. Almost all farmers bought cabbage seeds or seedlings in 1990, whereas less than one quarter bought certified seed potatoes, and none purchased spring onion seeds (Table 21).[68] These differences are understandable. Good quality cabbage seeds are difficult to produce and can be bought at a low cost, although farmers have been complaining about a drop in quality standards in recent years. Certified seed potatoes are expensive, and farmers can easily use smaller tubers of the previous harvest for this purpose.[69] Certified potato seeds can be bought at a KGGCU branch or from one of the private stockist that are appointed by the KGGCU. However, the branch offices and dealers do not always have large quantities in stock, because they fear the sprouting of the tubers. Moreover, the ADC farm at Molo, where certified seed potatoes are multiplied, is not always able to supply the KGGCU and stockists. Although the number of farmers using certified seed potatoes had increased in comparison with the 1970s[70], over three-quarters of the farmers still use their own potatoes for seed, which is worrisome, especially in the light of rising seed-born diseases like bacterial wilt. The situation for spring onions is somewhat similar to potatoes, in the sense that farmers can easily use small off-shoots as seedlings for the next crop. Problems with diseases have not yet occurred, because of the relatively recent start of intensified production. However, if they appear, availability of certified seed will be a problem.

Farmers in Nyandarua use combinations of fertilizers, manure and sometimes mulch in order to keep the soil fertile and secure a successful harvest. Almost all farmers applied fertilizers to the potato and cabbage crop, but only a minority used them in spring onion production. We will look at fertilizers in more detail in the next section. Manure was also widely used, although we did not come across farmers who bought dung, since most of them possessed cattle.[71] A few farmers bought mulch to be applied on plots with potatoes.

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[68] Those who did not buy cabbage seed or seedlings most probably received them free of charge from relatives or friends.

[69] The germinating power of some varieties has gone down, while cabbage seeds of the Copenhagen variety for instance were found to be mixed with Drumhead.

[70] According to a survey by Durr and Lorenz among potato farmers in Nyandarua and elsewhere in 1976/77 non of the Nyandarua farmers used certified seed potatoes (Durr and Lorenz, 1980).

[71] Part of the animal dung normally got lost, because zero-grazing was not practiced.

Pesticides and fungicides are applied by farmers in order to battle pests and diseases. Over 60% of the farmers used them for potatoes, which suggests that over half of the potato crops in the horticultural areas were infected or in danger of infection during some growth stage. Potato production was indeed hampered by different types of diseases, including late blight and the already mentioned bacterial wilt.[72] Late blight, which is a common soil-born disease in areas with high precipitation, can only be prevented by strict crop rotation, and controlled by fungicides. It also attacked cabbages, which, in general, needed fewer chemicals than potatoes (Table 21). The reason is most probably a less intensified production (see section 4.2). Spring onions did not need any chemicals at all, mainly because of a relatively recent start of commercial production.

Apart from land preparation, farmers required labour for weeding, ridging (in case of potatoes), harvesting and packing of the produce. Most of the farm labour was done by household members but some was carried out by hired labourers. They were normally casuals but could also be permanently employed, especially in the case of larger farms that provided work the whole year through. Casual labourers were rewarded according to various systems, of which daily payments were the most common. Alternative approaches were payment per bag when harvesting, and payment per job when ploughing. The latter type of contract work was common for small groups of young men, who negotiated a lump sum in relation to the size of the plot. Groups of women might also carry out contract work, especially when transplanting cabbages. As an alternative to those labour groups, farmers might organize voluntary groups themselves to work for each member in turn in exchange for a good meal offered by the host.

Table 22 shows the importance of hired labour for the different farm activities. The comparison with family labour is not based on man-days, but on costs, in order to incorporate hired tractor services. Unpaid labour by family members comprised around 70% of the total requirements for all activities in the case of potatoes and cabbages, and over 80% in the case of spring onions. As for preparation and sowing/transplanting of the first two crops, family labour was responsible for less than half the total requirements, not only because of hired labour but also because of substantial tractor inputs. Hired labour for harvesting was less important with cabbages than with potatoes, because cabbages were often harvested gradually which eased labour constraints. Cultivation of

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[72] The Latin names of the two diseases are Pseudomonas solanacearum (bacterial wilt) and Phytophthora infestans (late blight).

spring onions was, more than other crops, a family affair, because of the smaller holdings and related smaller production of vegetables in Geta Location.

Table 22. Contributions of hired labour, tractor services and household labour to the total labour requirements, 1990 (%)

	potatoes (n=155)			*cabbages (n=27)*			*spring onions (n=16)*		
	hired labour	*tractor service*	*family labour*	*hired labour*	*tractor service*	*family labour*	*hired labour*	*tractor service*	*family labour*
land prep., sowing*	27	30	43	25	25	50	29	0	71
weeding**	21	-	79	27	-	73	14	-	86
harvesting	20	-	80	12	-	88	7	-	93
average all activities	22	10	68	21	9	70	18	0	82

See Appendices 24, 25 and 26
* Nursery work and transplanting involved in cabbage cultivation is included.
** Potato ridging is included.

The majority of the hired labourers are women. This is especially true of weeding, where 88% (potatoes) to 69% (cabbages) of the hired labour consisted of women in 1990.[73] Only land preparation and potato sowing was a more male than female affair. This can be explained by the nature of the work involved, which requires considerable strength, especially when early rains have moistened the soil. Hired female labour prevailed in soil preparation and planting of cabbage, first because this crop needs less soil inversion, and second because transplanting cabbage seedlings is less strenuous. Harvesting was, again, a more female than male job. Thus women were the most important contributors to horticultural farming in Nyandarua as far as hired labour was concerned. This does not automatically mean that they were also the main beneficiaries of the incomes derived from their activities.

Comparing wage levels by gender reveals some differences between male and female casuals. In the case of potatoes, about which we have most observations, both sexes were paid equally to weed, whereas men received on average one Shilling more to plough and three Shillings more to harvest.[74] This suggests that men were only paid higher wages than women in case of heavier jobs. Altogether, daily wages ranged from KSh 23 to KSh 40, depending on the type of work and the location. The latter variable was also quite important, as is shown by the average wages for weeding, which were KSh 23 in Geta

[73] See Appendices 24 and 25.
[74] See Appendix 24.

location, while they were above KSh 30 elsewhere. Labour availability seemed to be less of a problem in Geta, which affected the wages of casual workers.

One last category of inputs and related costs has to be mentioned, namely farm implements such as knapsack spray pumps, *jembes*, *pangas*, and wheelbarrows.[75] These items were normally bought by farmers, but spraying pumps might also be borrowed from neighbours in view of the relatively high cost and irregular use. Some farmers designed their own equipment, such as a sowing machine made out of a stick and a small tin.

5.2. Costs and benefits of potato production

Rising input prices and declining profitability

According to our farm survey, average potato yields in the UH1+2 zone were more than twice as large as in the UH3 zone. Comparable cost levels and lower yields resulted in a considerably smaller net income per acre in the latter zone (Table 23). Figure 4 shows the composition of the the gross potato income in both zones.

Under 1990 conditions potato production was profitable in both zones. However, between 1990 and 1992 the costs of inputs increased considerably. The price of a 50kg bag of DAP fertilizer, for instance, changed from KSh 350 to KSh 600 in Kinangop Division, while the cost of half a kilogram of Ridomil fungicide doubled from KSh 225 to KSh 450. Both increases where caused by a fading out of government subsidies on inputs and an on-going depreciation of the Kenyan Shilling. Apart from fertilizers and pesticides, the costs of labour augmented. A casual labourer who owned KSh 30 per day in 1990, received KSh 50 in 1992.

The cost increases were not compensated by higher returns, as the farm-gate prices for potatoes did not change (see section 3.4). Therefore, the net income and profit per acre of potato production have declined considerably. Table 24 shows the cost-benefit analysis when calculated against 1992 input prices, while Figure 5 compares the 1990 and 1992 profits. The net incomes remained positive in both zones, but the final profits after

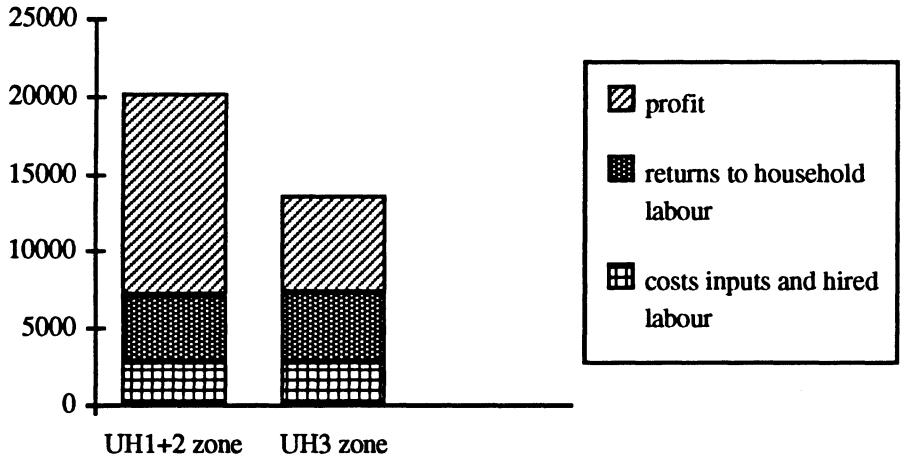
[75] Such equipment can be used for more than one crop cycle, which means that farmers have to calculate depreciation cost.

Table 23. Cost-benefit analysis of potato production by zone, 1990 [76]

	UH1+2 zone (n=100)		*UH3 zone (n=55)*	
seed potatoes (KSh/acre)	972		1100	
fertilizer (KSh/acre)	780		546	
bought mulch (KSh/acre)	3		0	
pesticides/fungicides (KSh/acre)	195		363	
tractor services ploughing (KSh/acre)	205		165	
tractor services harrowing (KSh/acre)	37		29	
hired casual labour (KSh/acre)	367		339	
rent land (KSh/acre)	0		9	
Total variable cost (KSh/acre)		2,557		2,551
hired permanent labour (KSh/acre)	126		157	
spraying pump (KSh/acre)	121		96	
Total fixed cost (KSh/acre)		247		253
Total cost (KSh/acre)		2,806		2,804
Total harvest (bags/acre)	72		35	
average farm-gate price (KSh/bag)	180		180	
Gross income (KSh/acre)		12,960		6,300
Net income (KSh/acre)		10,154		3,496
including: - returns to household labour		1,568		1,613
- profit		8,586		1,883

source: farm survey and Appendix 24
Note:The returns to household labour were calculated by deducting the costs of tractor services, hired casual and hired permanent labour from the total estimated labour cost as given in Appendix 24.

Figure 4. Composition of average gross potato income by zone, 1990 (KSh/acre)



[76] Out of the 138 farmers in the UH1+2 zone and 88 farmers in the UH3 zone who planted potatoes, 100 and 55 respectively were asked about cultivation costs.

deducting the returns to family labour became negative in the UH3 zone. It can therefore be concluded that potato production against 1992 input prices was no longer profitable in this zone. The consequences of the higher input costs were smaller in the UH1+2 zone because of higher yields. In general, yields decline if farmers use less inputs in an attempt to cope with the higher costs. Average expenditures on fertilizer were already below the recommended level in 1990, meaning insufficient use of DAP.[77] Further economizing on fertilizers will affect potato yields in the short run and the fertility of the soil in the long run.

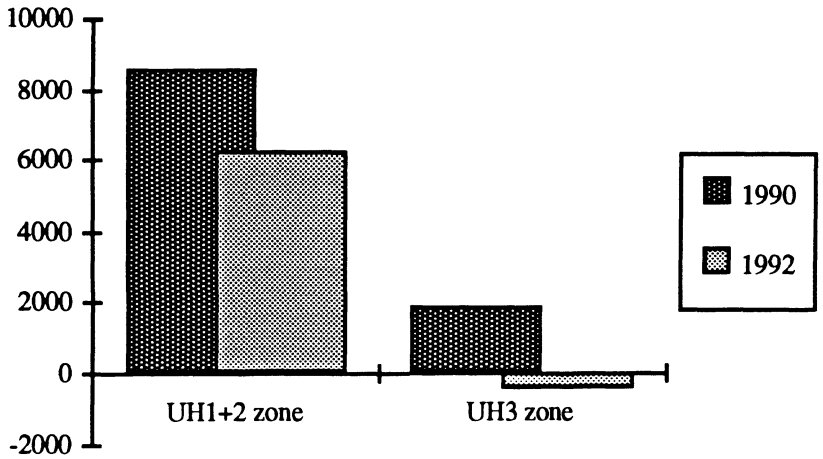
Table 24. Cost-benefit analysis of potato production by zone against 1992 input prices

	UH1+2 zone (n=100)		*UH3 zone (n=55)*	
seed potatoes (KSh/acre)	972		1100	
fertilizer (KSh/acre)	1,334		934	
bought mulch (KSh/acre)	3		0	
pesticides/fungicides (KSh/acre)	390		726	
tractor services ploughing (KSh/acre)	359		289	
tractor services harrowing (KSh/acre)	59		46	
hired casual labour (KSh/acre)	613		566	
rent land (KSh/acre)	0		9	
Total variable cost (KSh/acre)		3,730		3,670
hired permanent labour (KSh/acre)	210		262	
spraying pump (KSh/acre)	142		112	
Total fixed cost (KSh/acre)		352		374
Total cost (KSh/acre)		4,082		4.044
Total harvest (bags/acre)	72		35	
average farm-gate price (KSh/bag)	180		180	
Gross income (KSh/acre)		12,960		6,300
Net income (KSh/acre)		8,878		2,256
including: - returns to household labour		2,619		2,694
- profit		6,259		- 438

Note: The calculations are based on the same input levels as for 1990 (see Table 24). The cost increase ratios are: 1.71 for fertilizer (from KSh 350 to KSh 600 per 50kg DAP), 2.00 for pesticides/fungicides (based on Ridomil: from KSh 225 to KSh 450 per 0.5kg bag), 1.67 for casual, permanent and family labour (based on casual labour: from KSh 30 to KSh 50 per day), 1.75 for ploughing by tractor (from KSh 400 to KSh 700 per acre), 1.60 for harrowing (from KSh 250 to KSh 400 per acre) and 1.17 for the spraying pump (from KSh 1,500 to KSh 1,750 buying price). The cost for seed potatoes was kept at the same level, first because the price of certified seed potatoes remained almost constant (from KSh 250 to KSh 265 per 50kg bag), and second because most farmers used their own seed of which the farm-gate price did not change.

[77] Extension officers recommended four 50kg bags of DAP, costing KSh 350 per bag in 1990.

Figure 5. Profitability of potato production by zone against 1990 and 1992 input prices (KSh/acre)



Seasonal price fluctuations, crop scheduling and storage

Tables 23 and 24 show an off-farm price of KSh 180, which was the annual average for the district in 1990. However, prices fluctuated considerably throughout the year, ranging from KSh 80 to KSh 365 per bag. The fluctuations were caused by two factors: seasonal supply changes at the national level and varying transport costs. Seasonality of national supply normally results in higher prices in April - May, and lower prices in August - September.[78] The latter price drop was, however, not as large in 1990 as before, because of a disappointing harvest in Meru District, one of the other main suppliers of potatoes to the Nairobi market. The variation in transport costs was caused by the rainfall pattern and related road conditions. Accessibility problems in 1990 did not differ from those in other years.[79]

Given the seasonal price fluctuations, it is important to know the break-even price, that is the selling price that would have equalled total costs and total benefits per acre of potato production. If we look at the farm as a sustainable enterprise, the costs should include returns to family labour. After some calculations it can be concluded that the minimum price per bag of potatoes should have been KSh 60 in the UH1+2 zone and KSh 126 in

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[78] This was found by Durr & Lorenz (1980) during analysis of wholesale prices in Wakulima market, Nairobi, between 1973 and 1977.

[79] It is difficult to estimate to what extent the price fluctuations at the farm gate were caused by the national supply factor and to what extent by the accessibility factor. It can, however, be concluded that both were of importance because prices in Nairobi market fluctuated less than at the farm gate.

the UH3 zone in 1990.[80] The first price is lower than the lower limit of KSh 80, which means that farmers in the UH1+2 zone made a profit under all circumstances in 1990. However, the second break-even price was far above this limit, which means that farmers in the UH3 zone incurred a considerable loss if they sold their potatoes at the wrong time of the year. When repeating the exercise against 1992 input prices, the break-even price in the UH1+2 zone becomes KSh 93 and in the UH3 zone KSh 192.[81] Under those circumstances farmers in the UH1+2 zone had to deal with a loss whenever farm-gate prices were relatively low, while farmers in the UH3 zone only made a profit when farm-gate prices were relatively high.

There are two ways of decreasing or preventing such losses. First, to improve the accessibility of the area under all weather conditions; this would increase the number of traders and decrease the transport cost for each of them, so that they would be inclined to offer a better price. Second, farmers should try to plan their harvests outside the national supply peaks by means of crop scheduling; for this, they need support from the Nyandarua extension staff, who should supply information about seasonal price fluctuations in the urban markets.

It might also be beneficial to promote on-farm storage during harvesting peaks. This has been tried in the past through various programmes, but without success. Farmers seem to be in immediate need of money and therefore sell their crop as soon as possible. Moreover, they find storage for more than a couple of days too risky because of the excessive rains that cause rot very quickly, especially if roofed storage facilities are lacking. Indeed, farmers seem to regard postponed harvesting as a better alternative, although this cannot be done indefinitely because full-grown potatoes will rot if the soil is saturated.

Storage by farmer groups might serve as an alternative to storage by individual households. The group could apply for a loan, not only to built a store but also to finance stocks solving the immediate need of money of its members. However, activities by farmer groups may lead to management problems similar to the ones experienced by existing cooperative societies. Moreover, storage should only be promoted if storage losses do not nullify the benefits of higher future selling prices.

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[80] The total costs including family labour were KSh 4,374 in the UH1+2 zone and KSh 4,417 in the UH3 zone (see Table 23). Dividing these figures by the number of harvested bags per acre in both zones gives the break-even prices at the farm gate.

[81] The total costs including family labour become KSh 6,701 in the UH1+2 zone and KSh 6,739 in the UH3 zone (see Table 24).

5.3. Costs and benefits of cabbage production

The costs and benefits of cabbage production against 1990 and 1992 input prices are presented in Table 25.[82] The cost increases change the profitability of cabbage production drastically. In 1992, cultivation of cabbages for sale was no longer profitable in both

Table 25. Cost-benefit analysis of cabbage production against 1990 and 1992 input prices (n=27)

	1990 input prices		*1992 input prices*	
seed (KSh/acre)	211		293	
fertilizer (KSh/acre)	408		714	
bought mulch (KSh/acre)	0		0	
pesticides/fungicides (KSh/acre)	134		268	
tractor services ploughing (KSh/acre)	146		256	
tractor services harrowing (KSh/acre)	49		78	
hired casual labour (KSh/acre)	269		449	
rent land (KSh/acre)	0		0	
Total variable cost (KSh/acre)		1,217		2,058
hired permanent labour (KSh/acre)	192		321	
spraying pump (KSh/acre)	52		61	
Total fixed cost (KSh/acre)		244		382
Total cost (KSh/acre)		1,461		2,440
	UH1+2 zone	*UH3 zone*	*UH1+2 zone*	*UH3 zone*
total harvest (bags/acre)	50	40	50	40
average farm-gate price (KSh/bag)	100	100	100	100
Gross income (KSh/acre)	5,000	4,000	5,000	4,000
Net income (KSh/acre)	3,539	2,539	2,560	1,560
incl.: - returns to household labour	1,538	1,538	2,568	2,568
- profit	2,001	1,001	- 8	-1,008

source for 1990 figures:farm survey and Appendix 25

Notes: The returns to household labour in 1990 were calculated by deducting the costs of tractor services, hired casual and hired permanent labour from the total estimated labour cost as given in Appendix 25.
The calculations against 1992 input prices are based on the same input levels as for 1990. The cost increase ratios are the same as for potatoes (see Table 24), except for seed and fertilizer: 1.75 for fertilizer (from KSh 285 to KSh 500 per 50kg TSP), 2.00 for pesticides/fungicides (based on price increases of pesticides like Rogor-E), 1.67 for labour, 1.75 for ploughing, 1.60 for harrowing and 1.17 for the spraying pump. Costs for seed are assumed to have risen in accordance with inflation, as they were not subsidized and produced locally. The official inflation rates were 16% in 1990 and 20% in 1991 (CBS, 1992).

[82] The calculations are based on zone-specific yields because of considerable differences from one zone to another. It is assumed that the input costs do not differ from one zone to another. This is based on the results for potatoes where the input costs in both zones were also of about the same magnitude.

zones, that is when calculated against the average annual selling price.

The farm-gate price fluctuated between KSh 60 and KSh 300 in 1990. The break-even prices in the UH1+2 and UH3 zones were KSh 60 and KSh 75 respectively when calculated against 1990 input prices, and KSh 100 and KSh 120 respectively when using 1992 input prices. It can, therefore, be concluded that cabbage farmers in the former zone made a profit in 1992 as soon as the selling price was a little above the annual average, while farmers in the latter zone had to wait for a considerably higher price. This entailed crop scheduling and off-season production, which might require irrigation, meaning buying pumps and sometimes building dams or water basins. Apart from the technical knowledge, which should be provided by extension officers, farmers need credit for such investments. However, many of the conditions set by the lending agencies such as the Agricultural Finance cannot be met by the farmers concerned. Without money to invest, these farmers start the production process on the wrong footing.

5.4. Costs and benefits of spring onion production

The costs and benefits of spring onion production according to 1990 and 1992 input prices are presented in Table 26. The figures refer to Geta location in the UH1+2 zone, where commercial production of the crop was concentrated.

The profit as percentage of the gross income was quite high for spring onions compared to the other crops. There are two reasons for this: first the relative small labour requirements (both hired and household labour) and second the low levels of fertilizer, pesticide and fungicide applications. The latter was possible because of the fertile soil and short history of commercial horticultural production in Geta Location. These locational circumstances, however, have certain implications. The same crop will be less profitable in other areas where the soil is less fertile and horticultural crops have been grown for a longer period. Moreover, the fertility of the soil in Geta Location will deteriorate quickly within the coming decade if farmers do not apply sufficient fertilizer, the more so because of the relatively small size of the holdings and related intensity of production. Lower yields will affect vegetable incomes, which were already relatively low compared to the other parts of the UH1+2 zone (see section 3.2). Therefore, proper extension services and availability of fertilizers are more important in this area than anywhere else.

Table 26. Cost-benefit analysis of spring onion production against 1990 and 1992 input prices (n=16)

	1990 input prices		*1992 input prices*	
seed (KSh/acre)	0		0	
fertilizer (KSh/acre)	26		46	
bought mulch (KSh/acre)	0		0	
pesticides/fungicides (KSh/acre)	0		0	
tractor services ploughing (KSh/acre)	0		0	
tractor services harrowing (KSh/acre)	0		0	
hired casual labour (KSh/acre)	173		289	
rent land (KSh/acre)	0		0	
Total variable cost (KSh/acre)		199		335
hired permanent labour (KSh/acre)	70		117	
spraying pump (KSh/acre)	0		0	
Total fixed cost (KSh/acre)		70		117
Total cost (KSh/acre)		269		452
total harvest (bags/acre)	18		18	
average farm-gate price (KSh/bag)	300		300	
Gross income (KSh/acre)		5,400		5400
Net income (KSh/acre)		5,131		4,948
incl.: - returns to household labour		1,131		1,889
- profit		4,000		3,059

Source: for 1990 figures: farm survey and Appendix 26
Note: The calculations for 1992 are based on the same input levels as for 1990. The cost-increase ratios are.the same as for cabbages: 1.75 for fertilizer and 1.67 for labour (see Table 25).

6. Conclusions and recommendations

Horticulture is an important source of income and employment in Kenya. Nyandarua is one of the main vegetable producing districts of the country. Its farmers have developed a flourishing horticultural industry during the last decades, making it one of the main sources of cash revenues for the majority of the households in the district (see section 3.2). Future cultivation of the commodities is, however, endangered by various developments and constraints.

At present, one of the most important constraints concerns rising costs of inputs which affect the profitability of the horticultural enterprise (see sections 5.2 and 5.3). During the last few years, prices have risen all over Kenya as a result of the scaling down of subsidies as part of the structural adjustment programme, and more expensive imports due to depreciation of the Kenyan Shilling. Farmers in Nyandarua react by abandoning vegetable production for the market, especially in areas with lower yields where horticultural production is no longer profitable for most of the year (the UH3 zone, see section 3.4).

Another important constrain is the poor infrastructure of Nyandarua District (see section 3.3). Part of the rural access and minor roads have been improved through donor funding, but many more are in still in a deplorable state. Major roads are waiting for up-grading by the Ministry of Public Works, but lack of funds have hampered any activity in this direction. Clearly Nyandarua does not get the priority it deserves as one of the major producers of vegetables in the country. Improvement of the infrastructure has to guarantee the profitability of horticulture in the district, and therefore the supply of vegetables to urban consumers in Central Province and elsewhere.[83]

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[83] The marketing of horticultural commodities is the subject of a separate report (part 2B: Horticultural Marketing in Nyandarua District).

A recurrent problem in Nyandarua (as well as other parts of Kenya) concerns the scarcity of certain types of seeds (see section 5.1). The KGGCU has appointed private stockists who have increased the availability of inputs in the rural areas, but popular seeds of new varieties are often difficult to obtain or very expensive. This hampers the diversification of vegetable production in Nyandarua. Quality deterioration of Kenyan-produced seeds is also a problem, affecting yields and profits. Constraints with regard to importation and distribution of vegetable seeds should be solved, and the quality control system at Kenyan seed multiplication farms improved.

Research efforts to explore new vegetables and fruits with good market prospects should also be increased. Apples, for instance, have been regarded as a promising commodity in Nyandarua for many years, but district agricultural officers lacked support from the agricultural research institutes in testing varieties and multiplying rootstocks (see section 4.5). Support has also been lacking in the cut-flowers sector, leaving the district extension staff without sufficient knowledge about production and post-harvest techniques (see section 1.3).

Another problem in the cut-flowers sector concerns royalty payments with regard to planting material. Small-scale flower production will generate income as long as farmers have access to species and varieties that are fashionable in the international market. This is, however, often not the case (see section 1.3). The Kenyan government needs, first, to negotiate with foreign multiplication farms on behalf of the small-scale producers, and, second, to subsidize those farmers by paying part of the royalties during the period that the industry is in its infancy. In addition, agricultural research institutes should try to identify promising cut-flower species that are not subject to royalties.

Many vegetable farmers in Nyandarua have to cope with low selling prices and economic losses due to lack of market-oriented production (see section 5.2). Extension messages by the district extension staff should be focussed on crop scheduling. This may even imply postponement of vegetable planting during the long rains. Such a message will only be adopted if alternative crops are suggested for growing in the grace period. Research is needed on the latter. Possibilities include oats for cattle feed and crops for the production of edible oil. Trials need to be carried out at the Farmer Training Centres in the district under supervision of the national agricultural research institutes.

Extension messages should also focus on crop rotation, appropriate use of inputs and the afore mentioned diversification of production. Such practices are necessary to fight

diseases like bacterial wilt and late blight, and to avoid degrading of the quality of the soil (see section 5.2). The private stockists that are appointed by the KGGCU could serve as intermediaries in advising farmers about optimal use of inputs. They should first be trained by the extension staff, and thereafter be supplied with periodical leaflets to keep their knowledge up-to-date. Leaflets can also be used to instruct farmers, because most households have members who can read nowadays and the message could be explained in more detail than on fertilizer bags and seed and pesticide packages. Extension should be based on an integrated approach to horticulture and livestock, as these sources of income are closely related (see section 4.4).

Extension messages should be backed by credit schemes through existing financial institutions like cooperative and private banks. Credit is needed, for instance, to invest in irrigation during off-season production on the lower slopes of the Aberdares, and in the purchase of nets and appropriate inputs for cut-flower production (see sections 5.3 and 1.3). The credit facilities should be extended to stockists under supervision of the KGGCU, in order to finance their purchase of sufficient quantities of high-quality inputs. Finally, credit should be made available to finance vegetable stocks of farmer groups wanting to store produce during supply peaks in order to fetch a better price in the market later on in the year (see section 5.2).

In conclusion, for the horticultural sector in Nyandarua to play its future part as food supplier for the country and source of income for the farmers concerned sufficient support through extension, research and national policy measures is needed. Without such backing there is a real danger that farmers will revert to subsistence agriculture and livestock production. With proper support they may be expected to further develop horticulture into a prosperous industry, supplying vegetables to the increasing urban population of Kenya.

Appendices

Appendix 1. Agricultural land and rural population by zone, 1990 *

Location/ Division	*UH1+2 zones*		*UH3 zone*		*other zones*		*total all zones*	
	sq km	*pop*	*sq km*	*pop*	*sq km*	*pop*	*sq km*	*pop*
Ol Joro Orok Div.	175	21,584	62	7,708	73	9,250	310	38,542
Dundori+Tumaini	167	28,112	0	0	22	3,833	189	31,945
Rurii	32	4,531	32	4,531	47	6,563	111	15,625
Ol Kalou+Kaimbaga	33	2,865	80	6,684	113	9,548	226	19,097
Ol Kalou Division	232	35,508	112	11,215	182	19,944	526	66,667
Wanjohi	14	1,771	87	10,625	45	5,312	146	17,708
Kipipiri+Lereshwa	23	3,667	28	4,583	137	22,306	188	30,556
Geta	30**	17,709	0	0	0	0	30	17,709
Kipipiri Division	67	23,147	115	15,208	182	27,618	364	65,973
Leshau+Kiriita+ Mathingira	3	611	20	3,972	134	25,973	157	30,556
Ndaragwa+Shamata	55	8,333	74	11,111	105	15,278	234	34,722
Ndaragwa Division	58	8,944	94	15,083	239	41,251	391	65,278
North. Kinangop+ Engineer	99	14,184	124	17,812	7	990	230	32,986
Magumu+Nyakio	79	14,802	79	14,802	3	605	161	30,209
South Kinangop	83	17,222	50	10,556	0	0	133	27,778
Kinangop Division	261	46,208	253	43,170	10	1,595	524	90,973
Total district	793	135,391	636	92,384	686	99,658	2,115	327,433

Source: MPND, 1989d: Jaetzold, R. and H. Schmidt, 1983.

*It is assumed that the population is equally spread within a location, regardless of the agro-ecological zone.

**According to Jaetzold and Schmidt (1983), Geta Location consists entirely of forest reserve. However, during the 1980s, part of the reserve was opened up and developed as a settlement area. It is assumed that the area concerned covered 50% of the total division in 1990.

Appendix 2. Production values of various agricultural commodities in Nyandarua District, 1990

commodity	*value (KSh '000)*
maize	4,447
wheat	1,236
total cereals	5,683
pyrethrum	2,610
potatoes	11,520
cabbages	3,843
green peas	2,413
carrots	716
spring onions	252
bulb onions	586
kale	186
plums	86
pears	126
peaches	38
apples	720
tomatoes	22
total vegetables and fruits	20,508
floriculture	2,218

Source: MOA, 1990

Appendix 3. Pan African Vegetable Products Ltd.

Perhaps one of the most interesting cases of vegetable processing in Kenya is the story of Pan African Vegetable Products Ltd. in Naivasha. This company was started as Panafood Ltd. by a German company named Brickner-Werk in 1964, just after Kenya attained independence. A dehydration plant was built with the aim to earn Kenya foreign exchange by selling dehydrated vegetables overseas, to prolong shelf life of vegetable produce, to reduce its bulkiness in order to save cargo space and reduce transport costs, and last but not least to alleviate marketing problems of farmers in and around Naivasha. Those farmers resided first of all in Kinangop Division, Nyandarua District.

In the mid 1970s the Kenya government acquired shares and hence went into partnership with the German company, in order to assure remittance of the foreign exchange that was earned after selling the vegetables abroad. The name of the company was changed into Pan African Vegetable Products Ltd. The government made land available which could serve as nucleus estates for the company, in order to supplement the produce that was supplied by the farmers. In 1982 the company went into receivership because of mismanagement, only to be revived in 1986 under the auspices of the Industrial and Commercial Development Corporation (ICDC), a government parastatal. After its revival, the company focussed more and more on estate production instead of purchasing produce from farmers. The latter got frustrated and dropped out (see also section 1.3 of the main text). Almost all the produce that has been sustaining the company during recent years originates from its nucleus estates, which are however not able to supply sufficient raw material to keep the factory running at anything near full capacity.

With the experience of Panaveg Ltd. one needs to be careful in locating a vegetable processing plant. It may just be in the centre or adjacent to production areas but never be used to full capacity. Although the establishment of an extra marketing outlet for the producers could have been a good idea, it was not organized properly and the planners had miscalculated the competition they had to face from the fresh market. The latter paid higher prices and cash on delivery. The most important factor that has led to the misfortune of the factory is however the absence of an internal market for dehydrated vegetables and the inability to compete in the international market. This became especially clear when the German partner left the company in 1982, taking with him all his German contacts that up to then bought most of the produce. The factory has not been able to find substantial new long-term market outlets since, as competition in the international market is quite severe and the quality standards of Asian competitors are considerably higher. One could thus question the feasibility of a vegetable dehydration plant in Kenya.

In 1991 the plant was put up for sale by the ICDC, as part of the Structural Adjustment Policy of the Government. At the time of writing of this report, it was not clear whether a buyer had been already found.

Appendix 4. The farm questionnaire

Food and Nutrition Studies Programme (FNSP-11) ***Confidential***
Horticultural Farm Survey Nyandarua

Cluster nr ☐☐ **hh nr** ☐☐☐

Head of household

name	sex	marital status	educ	settler
	☐	☐	☐	☐

sex:
1: male
2: female

marital status:
1: single
2: married monogamous
3: married polygamous
4: divorced/ separated
5: widowed

education:
1: no formal educ
2: adult classes only
3: primary 1-4
4: primary 5-8
5: beyond primary

settler:
0: no
1: yes

main house(s):
1: mud
2: wood
3: stone/brick
4: other (spec)

Location of household

	name	code
Division		
Location		
Sub-location		

Size of holding ☐☐ acres

Size of household

	nr of residents	nr of part-time resid	nr of non-residents
up to 15 years			
16-59 years			
60+ years			

Household characteristics

nr of houses	main house(s)	nr of rooms in main house(s)
☐	☐	☐☐

Comments

Legend:hh=household, nr=number, educ=education, indiv=individual, resid=residents

	da mo yr	name assistant/supervisor
Interview	☐☐☐☐☐☐	
check	☐☐☐☐☐☐	
Coding	☐☐☐☐☐☐	
check	☐☐☐☐☐☐	
Data entry	☐☐☐☐☐☐	
check	☐☐☐☐☐☐	

nr of pages

Form 1	☐☐
Form 2	☐☐
Form 3	☐☐
Form 4	☐☐
Form 5	☐☐
Form 6	☐☐
Form 7	☐☐

CBS / Food and Nutrition Planning Unit
Ministry of Planning and National Development &
Egerton University & African Studies Centre-Netherlands

Form 1: Off-farm employment / livestock production

Confidential

cl nr | hh nr | page nr

off-farm employment (last 12 months)

nr	name	activity	code	type	inc per month	nr of months per year	place	com	vis

livestock production

A. animals

	number	sys	pur
(up) graded milk cow (mature females)			
sheep (mature animals)			
traditional cow (mature animals)			
other 1 (spec)			
other 2 (spec)			

B. daily milk sales:

	quant	un	price per un
-to KCC			
-local			

C. annual wool sales:

quant	un	price per un

Comments

Legend: cl=cluster, inc=income, com=commuting, vis=visits to the household, sys=system, pur=purpose of kept animals, quant=quantity, un=unit

type of employment:
1: (semi) permanent
2: casual
3: self employed
4: trading
5: food preparation
6: domestic labour

income per month:
1: less than 500 Kshs
2: 500 to 1500 Kshs
3: more than 1500 Kshs

commuting:
(enter only if place=2)
1: daily
2: weekly
3: less frequent

place:
1: in compound/ neighbourhood
2: elsewhere

visits to the household:
(enter only if commuting=3)
1: every 8 to 14 days
2: every 15 to 30 days
3: between terms
4: less than once a month
5: otherwise (spec)

system:
1: (semi) zero-grazing
2: free-range

unit:
1: kilogramme
2: bottle (specify)
3: other (specify)

purpose of kept animals:
1: animals are kept to be sold
2: animals are not kept to be sold

Form 2: Cash Crop Farming - 1

Confidential

cl nr | hh nr | page nr

A. vegetables (present crop)

plot nr	dist	own	annual rent (Kshs)	crop name	code	irr	sold until now	harvested until now	un	expected further sales	expected further harvest	un	number of crops per year

B. pyrethrum, cut flowers

nr	dist	own	rent	crop name	code	irr	average monthly sales	un

C. fruits

tree name	number of prod. trees	----last harvest---- sold	harvested	un	-coming harvest (exp)- sales	harvest	un

D. plots rented out

nr	dist	income (rent)

Comments

walking distance:
1: 1 to 15 minutes
2: 16 to 60 minutes
3: over 1 hour
4: beyond walking distance

irrigation:
0: none
1: river/well
2: pond/dam
3: tap
4: other (spec)

unit:
1: 90kg bag
2: debe
3: head
4: net
5: stem
9: other (spec)

ownership plot:
1: owned by household
2: rented from someone else
3: other (spec)

Legend: dist=walking distance, own=ownership plot, irr=irrigation, un=unit, prod=productive, exp=expected

Form 3: Cash Crop Farming - 2

Confidential

cl nr | hh nr | page nr

1. Check whether the farmer grows any horticulture for sale (Form 2)

Yes ☐ No ☐

If not, ask why and end interview after finishing this form.

(Tick the appropriate reasons)

- land shortage ☐
- labour shortage ☐
- poor soil ☐
- other cash crops more profitable ☐
- no possibility to sell the produce ☐
- other (specify) ☐

If yes, ask: do you grow smaller quantities of certain vegetables now, if compared to last year ? Yes ☐ No ☐

If yes, ask which vegetables and why ?

name vegetable	code	reasons

reasons:
1: crop rotation
2: produce could not be sold
3: selling price was too low
4: other (specify)

2. Are you a member of one or more cooperatives ? Yes ☐ No ☐

If yes, ask the name(s) and the activities performed

name cooperative	code	activities

activities:
1: input supply, 2: pyrethrum buying, 3: milk buying, 4: wool buying, 5: horticulture buying, 6:other (specify)

3. Do you have any complaints about this/these cooperative(s) ? Yes ☐ No ☐

If yes, ask the name of the cooperative(s) and the complaints ?

name cooperative	code	complaints

complaints:
1: payment delays, 2: high taxation on bought produce, 3: high membership fee, 4: low price paid for the commodity, 5: other (specify)

Comments

Form 4: Horticultural crops - selling

Confidential

cl nr | hh nr | page nr

crop nr	name horticultural crop	co	place of selling	if on farm: middlemen	if on farm: number	if in market: town	if in market: transport	if in market: produce of others	present price (Kshs)	un

Legend: nr=number, co=code, number= number of middlemen, transport=transport to the market, un=unit, spec=specify

Comments

place of selling:
1: on the farm/along the road
2: in the market

middlemen:
1: middlemen from within the area
2: middlemen from outside the area
3: both

number of middlemen:
1: farmer sells only to one middleman
2: farmer sells only to a few well known middlemen
3: farmer sells to whoever comes

produce of others:
1: only selling own produce
2: also selling produce of other farmers

town:
1: Nairobi
2: Nakuru
3: Naivasha
4: Limuru
5: Nyahururu
6: other (spec)

transport:
1: own vehicle (spec)
2: own vehicle, shared (spec)
3: hired vehicle (spec)
4: hired vehicle, shared (spec)
5: bus/matatu
6: otherwise (spec)

unit:
1: 90kg bag
2: debe
3: head
4: net
5: stem
9: other (spec)

Form 5: Horticultural crops - cultivation costs

Confidential

cl nr | hh nr | page nr

How do you know the selling prices of the horticultural crops at the moment you want to sell them?

Tick appropriate source(s)

- prices based on last year
- price information through friends, relatives
- price information through middlemen
- price information through traders in the market
- price information through the radio
- otherwise (specify)

Cultivation costs (chose one of the hort crops entered in Form 2)

crop specific costs:

plot nr | crop name | code | plot size (acres)

	total Kshs
tractor hire for ploughing	
tractor hire for harrowing	
seed/seedlings	
fertilizer	
pesticides	
other (spec)	

overhead costs:

	total Kshs
spraying pump	
other tools (spec)	

permanent workers:
- nr of workers
- total Kshs per month

hired labour for:	Kshs per person per day	nr of persons	nr of days	total Kshs
-ploughing by men*				
-ploughing by women*				
-sowing/planting by men*				
-sowing/planting by women*				
-weeding by men*				
-weeding by women*				
-harvesting by men*				
-harvesting by women*				

*In case of contract work enter only total Kshs!

Comments

Legend: hort=horticulture, nr=number

Form 6: Horticultural crops - selling costs

Confidential

cl nr | hh nr | page nr

Enter the same crop as in Form 5

plot nr | name crop | code

Attention: enter only costs paid by the farmer himself

packing costs	costs per un (Kshs)	un
hired labour for sorting		
hired labour for washing		
hired labour for filling of bags		
hired labour for topping up of bags		
hired labour for twining of bags		
gunny bags/ nets		
string/twine		per ____ units
other 1 (spec)		

transport costs	costs per un (Kshs)	un	
hired labour for carrying to road			
hired transport to road			
hired labour for loading			nr of units per trip: ____
if hired vehicle: rent		per trip	
if own vehicle: maintenance costs		per year	
bus/matatu fees			
bus/matatu ticket (to and fro)		per trip	
hired labour for unloading/carrying			
hired handcart		per trip	
other 2 (spec)			

marketing costs	costs per un (Kshs)	
market fees		per trip
car/lorry/handcart admission		per trip
other 3 (spec)		

Comments

unit:
1: 90kg bag
2: debe
3: head
4: net
5: stem
9: other (spec)

Legend: nr=number, un=unit, spec=specify

Form 7: Comments

cl nr | hh nr | page nr

1.

2.

3.

4.

Appendix 5. General characteristics of households by cluster, 1990											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
size holding (acres)	10.1	7.9	9.1	6.8	3.6	7.5	22.0	14.1	13.0	16.4	10.8
nr or residents											
- 0 to 15 years	2.9	3.1	2.6	2.1	2.9	2.7	3.6	3.3	3.8	3.6	3.0
- 16 to 59 years	2.5	2.9	3.3	3.5	2.9	3.0	3.0	3.0	3.9	3.3	3.1
- 60+ years	0.5	0.2	0.3	0.2	0.3	0.3	0.6	0.1	0.2	0.3	0.3
nr of part residents											
- 0 to 15 years	0.0	0.0	0.0	0.1	0.1	0.0	0.2	1.7	1.0	1.0	0.4
- 16 to 59 years	0.7	0.8	0.7	0.7	0.8	0.7	0.9	1.1	1.4	1.2	0.9
- 60+ years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
total nr of res.	6.6	7.0	6.9	6.6	7.0	6.7	8.3	9.3	10.3	9.4	7.7
polygamous hh (%)	7	3	7	7	13	7	20	3	0	8	8
female headed hh (%)	23	10	10	23	33	18	17	17	7	13	17
level of education (%)											
- no formal education	47	47	33	17	43	37	37	30	7	24	33
- adult classes only	3	3	0	3	3	3	0	3	0	1	2
- primary level 1-4	10	13	27	23	13	17	23	13	53	30	22
- primary level 5-8	27	17	33	40	33	30	17	33	27	26	28
- beyond primary	13	20	7	17	7	13	23	20	13	19	15
Source: farm survey, 1990											

Appendix 6. Households cultivating and selling agricultural commodities by cluster, 1990 (%)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
vegetable cultivation	87	93	100	100	100	96	100	100	100	100	98
- potatoes	87	90	97	100	87	92	97	97	100	98	94
- other vegetables	47	67	27	70	97	61	83	90	97	90	72
vegetable growers selling	88	86	97	93	97	92	87	97	100	94	93
- potatoes	85	81	97	93	69	86	86	97	97	93	88
- other vegetables	71	85	100	76	100	87	80	93	97	90	88
fruit cultivation	77	73	73	87	87	79	70	70	77	72	76
fruit growers selling	52	55	14	31	80	47	4	10	9	8	33
pyrethrum cultivation	26	26	0	3	40	19	40	13	0	18	19
pyrethrum growers selling	50	77	0	0	50	58	75	100	0	78	63
cut-flower cultivation	0	0	0	3	0	1	0	0	0	0	0
cut-flower growers selling	0	0	0	100	0	100	0	0	0	0	0
Source: farm survey, 1990											

Appendix 7. Livestock by cluster, 1990											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
A) households with											
(up-) graded cows (%)	83	77	83	70	70	77	93	97	97	96	84
B) average nr of mature											
(up)graded cows per owner	2.9	4.3	1.9	2.2	1.8	2.6	3.6	3.2	3.1	3.3	2.9
C) hh's with cows selling											
milk to the KCC (%)	76	96	56	71	43	68	82	76	86	81	73
D) hh's with cows selling											
milk locally (%)	12	0	0	29	0	8	0	0	0	0	5
E) households with											
traditional cows (%)	0	0	0	0	0	0	0	0	7	2	1
F) average nr of mature											
traditional cows per owner	0	0	0	0	0	0	0	0	1.5	1.5	1.5
G) hh's with sheep (%)	60	73	47	63	67	62	63	67	53	61	62
H) average nr of mature											
sheep per owner	7.7	9.2	7.5	4.5	4.9	6.8	7.0	9.1	7.9	8.0	7.2
I) households with											
sheep selling wool (%)	56	73	21	5	85	48	84	10	0	31	42
Source: farm survey, 1990											

Appendix 8. Off-farm employment by cluster, 1990											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
households with off-											
farm income (%)	50	40	43	30	37	40	60	23	70	51	44
average nr of off-farm jobs											
of these households	1.1	1.4	1.2	1.2	1.0	1.2	1.0	1.3	1.4	1.2	1.2
average nr of months											
employed per year	10.4	11.9	10.5	10.7	12.0	11.1	12.0	10.2	10.6	10.9	11.0
type of employment (%):											
- permanent	59	76	40	64	27	53	56	55	77	63	57
- casual	6	0	20	9	0	7	0	0	0	0	4
- self-employed	24	12	40	18	36	26	33	11	7	17	23
- trading	12	12	0	9	36	14	11	22	13	15	14
- domestic labour	0	0	0	0	0	0	0	11	3	5	2
place of work (%):											
- neighbourhood	41	41	40	45	18	37	11	11	3	8	26
- elsewhere,											
+ commuting daily	18	18	0	9	45	18	50	11	10	24	20
+ commuting weekly	12	6	0	9	9	7	17	33	23	24	14
+ less frequent visits	29	35	60	36	27	37	22	44	63	43	40
Source: farm survey, 1990.											

Appendix 9. Definitions of economic variables

1. INCOME

gross farm income	value of total output of the farm (crops and livestock), whether sold or not -in case of crops: value output = yield * selling price (surplus area) or yield * buying price (deficit area) -in case of livestock: value output = sales of stock + value of stock used for domestic consumption, payments in kind and gifts + value of stock at end of accounting period - purchases of stock - value of stock obtained as payments in kind and gifts - value of stock at beginning of accounting period + value of livestock produce (e.g. milk, eggs, wool)	
total farm costs (total farm expenses)	value of all inputs used up or extended in farm production, but excluding family labour (includes both cash and non-cash items) = variable costs + fixed costs	
variable costs (variable expenses)	expenses that are allocatable to a particular crop or livestock enterprise, and that vary as to the level of the particular enterprise (includes also variable costs of using fixed capital inputs, e.g. petrol; and permanent labourers if employed for a specific crop or livestock-related task)	
fixed costs (fixed expenses)	expenses that do not vary as to the level of crop or livestock enterprises (includes both allocatable and non-allocatable costs, includes a depreciation allowance in case of capital inputs, includes land tax and rent in cash or kind with regard to land, includes also casual labourers when carrying out general maintenance work, excludes interest on capital, whether owned by the farm family or borrowed)	
net farm income	= gross farm income - total farm costs	measure of farm profitability used to compare the performance of farms
net farm earnings	= net farm income - interest paid on borrowed capital used for farming purposes	
net household income	= net farm earnings + any other household income (includes e.g. wage income or payments in kind from off-farm work)	measure of poverty; assessment of poverty or income distribution for policy or planning purposes

Appendix 9. continued

2. CASH INCOME/ FLOW

farm receipts	the value of cash received for the sale of agricultural output (excludes cash loans advanced for farm purposes, excludes value of subsistence output, includes value of livestock purchases)	
farm payments	the cash paid for goods and services purchased for farm use (excludes interest and principal payments on farm loans, excludes value of labour paid in kind, includes value of livestock purchases)	
farm net cash income/ flow	= farm receipts - farm payments (the value of livestock purchases is neutralized)	measure of the capacity of the farm to generate cash
farm cash surplus	= farm net cash flow + cash loans - interest and principal	measure of the self-sustainability of the farm in terms of working capital
net household cash income	= farm cash surplus + wages for any off-farm employment	partial measure of the welfare of the farm family (in relation to self-sufficiency in food production)

Source: FAO, 1980; Levin, 1991; MOA, 1989a

Appendix 10. Calculation method for various types of income

1. **net household income** = net farm income + net land income + net off-farm income

2. **net farm income** = net vegetable income + net fruit income + net pyrethrum income + net livestock income

3. **net vegetable income**

In order to estimate the total net vegetable income, the harvested quantity per plot per crop (FORM 2) was multiplied by the number of crops per year (FORM 2)[84] and the average annual selling price (Background Survey), whereafter the variable costs, allocated fixed cost (both FORM 5) and annual rent in case of hired plots (FORM 2) were deducted.[85]

The selling price per commodity was used because most households were self-sufficient as far as locally produced horticulture was concerned.[86] The selling price was always equal to the farm-gate price because all farmers sold their produce on the farm to middlemen (see report 2B of the series). The average farm-gate price per 90kg bag for the various vegetables were:

potatoes (extended bag) KSh 180 (8 debes)
kale (normal bag) KSh 50 (6 debes)
cabbages (extended bag) KSh 100 (nr of heads depends on their size)
green peas (normal bag) KSh 150 (6 debes)
bulb onions (normal bag) KSh 400 (6 debes)
carrots (extended bag) KSh 200 (8 debes)
spring onions (extended bag) KSh 300 (twice the size of a normal bag)

Per interview the variable costs of one vegetable were asked (FORM 5). These data were used to estimate the variable costs as percentage of the gross income for the missing cases. The costs included use of own seed ,which was of importance in the case of potatoes. The value of own seed potatoes was set at the selling price at the time of sowing, that is KSh 263 per bag. The sowing quantity per acre was set at 520 kg/acre, which was the average for Kinangop division (Durr & Lorenz, 1980). The estimated variable costs as percentage of the gross income were:

potatoes in the UH1+2 zone 23%, in the UH3 zone 40% (see also section 5.2 of the main text)

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[84] Harvested quantities did not differ to a large extent from one crop cycle to another (Background Survey).
[85] FORM refers to a specific page of the farm questionnaire (see Appendix 4). Background Survey refers to a small survey that was carried out prior to the farm survey, comprising open interviews with district officials and horticultural farmers. The results were used to develop the farm questionnaire and to estimate key figures not obtained through the farm survey.
[86] Otherwise the buying price might have to be used.

kale 25%

cabbage in the UH1+2 zone 24%, in the UH3 zone 29% (see also section 5.3 main text)

green peas in the UH1+2 zone 30%, in the UH3 zone 50%

carrots 50%

spring onions 5% (see also section 5.4 main text)

The fixed cost (spraying pump, permanent labour, other farm tools) were asked in all cases (FORM 5). They were allocated to the various commodities according to the relative size of the harvest. For the spraying pump a depreciation period of five years was used.

The total net vegetable income per household was calculated by adding up the results of all plots.

3. **net fruit income**

The net fruit income was calculated by multiplying the annual sales per fruit type (FORM 2) with the average selling price (Background Survey), after which the maintenance and harvesting costs were deducted.

The farmers normally sold their fruits at the farm gate. The average prices were:

apples KSh 35 per kg

plums KSh 50 per carton (3 debes)

pears KSh 280 per bag (7 debes)

The maintenance and harvesting costs were estimated as a percentage of the gross income, namely 10% (Background Survey). Sold quantities were used instead of the harvested quantities to calculate the total income because the opportunity costs of unsold produce were nil.

4. **net pyrethrum income**

The gross pyrethrum income was calculated by multiplying the average monthly sales during picking (FORM 2) with the number of harvesting months per year, which was estimated at 7 (thereafter the stems were either pruned or got dry; Background Survey). The cultivation costs were estimated at 0.16% of the gross income because of use of family labour and low fertilizer cost. Consequently, the gross and net pyrethrum income were considered to be equal.

5. **net livestock income**

The net livestock income was sub-divided into income out of livestock products, and income through value increase of the herd.

5.1. **milk**

The income out of milk comprised milk sales, own consumption by the household members and feeding to calves. The average total milk production per cow was estimated at 4.3 litres when lactating, including 2.7 litres sales (30%), 1.3 litre own consumption (63%), and 0.3 litre feeding to calves (7%). The lactating period was 13 months and the inter-calf period 15 months (see Leegwater et al., 1991).

The quantity sold was asked in the questionnaire, including both selling to the KCC and local sales (FORM 1).

The own consumption was estimated on the basis of the number of residents and part-time residents and an average daily consumption of 175 cc per person per day. Milk consumption by household members who worked elsewhere were weighted as follows (figures for full-time employed persons with one month leave a year):

daily commuting	0.67
weekly commuting	0.35
visit every fortnight	0.21
visit every month	0.14

Milk consumption of people who visited the household less frequently was not calculated. In case of part-time employment/activities elsewhere the ratios were adjusted in accordance with the duration of the job/activity (number of months). The number of months employed, and frequency of commuting/visiting were asked in the questionnaire for each person of the household with an off-farm activity (FORM 1).

Feeding to calves was based on an average figure for Kenya, as found by a survey in 15 districts by the National Dairy Development Programme (DDP) of the Ministry of Livestock (source: personal communication with Mr. Voskuil of DDP). Altogether, our estimates of the relative importance of own consumption, sales and calf feeding appeared to be about the same as found by the national survey, which shows their accuracy.[87]

5.2. **wool**

Annual wool sales were asked in the questionnaire (FORM 1)

5.3. **value increase herd**

The calculation of the annual value increase of herd was based on figures of the DDP (see also Leegwater, et al., 1991). The percentage-wise increase per annum was multiplied by the actual value per type of animal. The figures were:

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[87] According to the national survey the percentages were 29 own consumption, 63 sales and 8 feeding to calves (source: personal communication with Mr. Voskuil of DDP).

type of animal	*value increase (%)*	*value (KSh)*
(up)graded cow	12	6000
traditional cow	12	3500
sheep	25	440

The value increase of cows includes the value of bull calves.

5.4. **other animals**

Goats were not found in the surveyed clusters. Donkeys and chickens might be present at farms. Donkeys were however kept as means of transport and therefore not included in the income calculations. Chickens were only included when they were kept in large quantities for commercial purposes. Their value was set at KSh 60 per hen.

6. **net land income**

The net land income was calculated by adding up the annual rent received for each plot rented out. The gross and net land incomes were considered to be equal because of assumed absence of costs.

7. **net off-farm income**

The net off-farm income was calculated by asking the monthly income and number of months employed for each member of the household engaged in off-farm employment (FORM 1). The incomes were attributed to the household budget in relation to the distance to the place of work and frequency of visits to the household by the members concerned. The ratios were as follows:

place of work	*visits to the household*	*ratio*
in the neighbourhood	no travelling	1
elsewhere	commuting daily	0.90
elsewhere	commuting weekly	0.25
elsewhere	visit less frequent	0.15

In case of less frequent visits the person is assumed to send some money now and then or to bring relatively large amounts during his or her irregular visits. It has to be remembered that the persons concerned are part of the household and do not yet have their own household.

8. **Differences between income and cash income calculations**

8.1. **net vegetable cash income**

Only the sold quantities of produce where included (FORM 2). As for the variable cost, costs of own seed were excluded. This altered the estimated variable costs as percentage of the gross income in the case of potatoes to 12% in the UH1+2 zone and 20% in the UH3 zone.

8.2. **net livestock cash income**

Only milk sales, wool sales and income out of cattle selling were included. The first two were asked (FORM 1). The annual income out of cattle selling was based on the assumption that female calves where kept to expand the herd and male calves were sold after being fattened. The selling price was KSh 1500. As the inter-calf period was 15 months, a bull was born every 30 months. 25% of the bulls was estimated to die before being sold (Background Survey). Therefore, the annual revenues out of selling bulls was KSh 450 per cow.

9. **Calculating vegetable incomes against 1992 prices**

The cost increases of various inputs are given in Chapter 5 of the main text (see Tables 24 and 25). The new variable costs as percentage of the gross income were:

potatoes in the UH1+2 zone 27%, in the UH3 zone 54% (see also section 5.2 of the main text)
kale 40%
cabbage in the UH1+2 zone 38%, in the UH3 zone 47% (see also section 5.3 of the main text)
green peas in the UH1+2 zone 48%, in the UH3 zone 80%
carrots 80%
spring onions 6% (see also section 5.4 of the main text)

The new percentages for potatoes in case of cash income (excluding own seed potatoes) were:

potatoes in the UH1+2 zone 16%, in the UH3 zone 31%

Other cost increases were:

hired casual and permanent labour 67%
spraying pump and other tools 17%

Appendix 11, Average net household income by cluster, 1990 (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
net vegetable income	27276	27761	21715	32037	11254	24009	5006	10072	9653	8243	18097
net fruit income	1093	409	12	50	607	434	3	24	67	32	283
net pyrethrum income	428	361	0	0	454	249	1487	1554	0	1014	536
net livestock income	13631	19333	8504	8104	6428	11200	17262	16523	15581	16455	13170
total net farm income	42428	47864	30231	40191	18743	35892	23758	28173	25301	25744	32086
land income	0	0	7	63	46	23	125	144	212	160	75
net off-farm income	8080	9113	4122	5607	5919	6568	7080	2922	8957	6319	6475
total net household income	50508	56977	34360	45861	24708	42483	30963	31239	34470	32223	38636
Source: farm survey, 1990											

Appendix 12. Average net household cash income by cluster, 1990 (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
net vegetable cash income	20831	22027	15793	22834	10056	18308	3176	7363	5656	5398	13467
net fruit cash income	1093	409	12	50	607	434	3	24	67	32	283
net pyrethrum cash income	428	361	0	0	454	249	1487	1554	0	1014	536
net livestock cash income	8874	14346	3899	4387	2260	6753	9720	10500	10581	10267	8070
net farm cash income	31226	37143	19704	27271	13377	25744	14386	19441	16304	16711	22356
land cash income	0	0	7	63	46	23	125	144	212	160	75
net off-farm cash income	8080	9113	4122	5607	5919	6568	7080	2922	8957	6319	6475
net household cash income	39306	46256	23833	32941	19342	32335	21591	22507	25473	23190	28906
Source: farm survey, 1990											

Appendix 13. Income out of land by cluster, 1990											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
number of households											
renting out land	0	0	1	2	3	1	2	1	7	3	2
average land income *											
(KSh/household)	0	0	7	63	46	23	125	144	212	160	75
Source: farm survey, 1990											
* averages include households without income out of land											

Appendix 14. Actual cash income and cash income in case of a blocked Njabini-Kipipiri-Ol'Kalou road, 1990 (KSh/household)

	Tulaga		*Geta*		*Kahuru*			
	actual	*blocked*	*actual*	*blocked*	*actual*	*blocked*		
	1990	*road*	*1990*	*road*	*1990*	*road*		
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*		
net vegetable cash income	15793	11862	10056	7677	3176	2016		
net fruit cash income	12	12	607	607	3	3		
net pyrethrum cash income	0	0	454	454	1487	1487		
net livestock cash income	3899	3725	2260	2171	9720	9277		
net farm cash income	19704	15599	13377	10909	14386	12783		
land cash income	7	7	46	46	125	125		
net off-farm cash income	4122	4122	5919	5919	7080	7080		
net household cash income	23832	19728	19343	16874	21591	19988		
Source: farm survey, 1990 (actual cash income)								
Note: For assumptions with regard to the blocked road see section 3.3 of the main text.								

Appendix 15. Average net household income by cluster against 1992 input prices (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
net vegetable income	23814	24865	18654	26991	10131	20891	3051	5914	4637	4534	14757
net fruit income	1093	409	12	50	607	434	3	24	67	32	283
net pyrethrum income	428	361	0	0	454	249	1487	1554	0	1014	536
net livestock income	13631	19333	8504	8104	6428	11200	17262	16523	15581	16455	13170
total net farm income	38966	44968	27170	35145	17620	32774	21803	24015	20285	22035	28746
land income	0	0	7	63	46	23	125	144	212	160	75
net off-farm income	8080	9113	4122	5607	5919	6568	7080	2922	8957	6319	6475
total net household income	47046	54081	31299	40815	23585	39365	29008	27081	29454	28514	35296
See Appendix 10, section 9 for the calculation method											

Appendix 16. Households cultivating and selling vegetables by cluster, 1990 (%)

	UH1+2 zone												*UH3 zone*								*all zones*	
	Sabugo		*Melangine*		*Tulaga*		*Njabini*		*Geta*		*average*		*Kahuru*		*Karati*		*Mukeu*		*average*		*average*	
	(n=30)		*(n=30)*		*(n=30)*		*(n=30)*		*(n=30)*		*(n=150)*		*(n=30)*		*(n=30)*		*(n=30)*		*(n=90)*		*(n=240)*	
	hh cult	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*	*hh cult*	*cult sell*
potatoes	87	85	90	81	97	97	100	93	87	69	92	86	97	86	97	97	100	97	98	93	94	88
green peas	23	56	10	70	23	100	37	54	93	97	37	84	73	82	73	86	83	93	76	88	52	87
cabbages	27	85	67	85	7	100	53	81	0	0	31	84	43	30	73	96	80	100	65	83	44	84
spring onions	7	100	0	0	0	0	0	0	90	100	19	100	7	0	0	0	0	0	2	0	13	92
kale	13	77	17	76	0	0	0	0	3	100	7	71	3	0	0	0	3	0	2	0	5	60
carrots	0	0	7	100	0	0	0	0	13	23	4	50	3	100	0	0	3	100	2	100	3	67
bulb onions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	100	0	0	1	100	0	0

Source: farm survey, 1990

Abbreviations: hh cult=households cultivating, cult sell=cultivators selling

Appendix 17. Average quantities of vegetables harvested by cluster, 1990 (90kg bags/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
potatoes	164	139	154	170	16	128	29	63	69	54	100
cabbages	30	77	2	86	0	39	20	38	50	36	38
spring onions	3	0	0	0	27	6	0	0	0	0	4
green peas	1	1	3	4	11	4	5	8	7	7	5
kale	9	7	0	0	2	3	1	0	0	0	2
carrots	0	0	0	0	2	1	3	0	1	1	1
bulb onions	0	0	0	0	0	0	0	0	0	0	0
Source: farm survey, 1990											
Note: a 90kg bag does not necessarily weigh 90 kilogrammes and may be extended (see Appendix 10, section 3).											

Appendix 18. Average quantities of vegetables sold by cluster, 1990 (90kg bags/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
potatoes	128	105	108	118	9	94	20	46	46	37	72
cabbages	26	71	2	71	0	34	11	28	35	25	30
spring onions	3	0	0	0	27	6	0	0	0	0	4
green peas	0	0	2	3	11	3	4	6	5	5	4
kale	7	4	0	0	2	3	0	0	0	0	2
carrots	0	0	0	0	2	1	3	0	1	1	1
bulb onions	0	0	0	0	0	0	0	0	0	0	0
Source: farm survey, 1990											
Note: a 90kg bag does not necessarily weigh 90 kilogrammes and may be extended (see Appendix 10, section 3).											

Appendix 19. Average net vegetable income by cluster, 1990 (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
potatoes	23611	21514	21217	25053	2206	18720	2984	6602	6043	5209	13655
cabbages	2222	5900	188	6522	0	2966	1534	2638	3085	2419	2761
spring onions	988	0	0	0	7701	1738	0	0	0	0	1086
green peas	104	86	311	462	1148	422	363	734	423	507	454
kale	352	230	0	0	-29	111	26	0	1	9	72
carrots	0	31	0	0	228	52	99	0	100	66	57
bulb onions	0	0	0	0	0	0	0	98	0	33	12
all vegetables	27276	27761	21715	32037	11254	24009	5006	10072	9653	8243	18097
Source: farm survey, 1990											
Note: in case of kale in Geta the average input costs were higher than the average value of the harvested produce.											

Appendix 20. Average net vegetable cash income by cluster, 1990 (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
potatoes	17689	16544	15542	18023	1268	13813	2292	5263	3764	3773	10048
cabbages	1896	5319	100	4612	0	2385	607	1556	1654	1273	1968
spring onions	928	0	0	0	7581	1702	0	0	0	0	1064
green peas	17	36	151	199	1054	292	187	446	138	257	279
kale	300	107	0	0	-29	76	-9	0	0	-3	46
carrots	0	21	0	0	182	41	99	0	100	66	50
bulb onions	0	0	0	0	0	0	0	98	0	33	12
all vegetables	20831	22027	15793	22834	10056	18308	3176	7363	5656	5398	13467
Source: farm survey, 1990											
Note: in case of kale in Geta and Kahuru the average input costs were higher than the average value of the sold produce.											

Appendix 21. Statistical analysis regarding determinants of the gross potato income in the UH1+2 zone

The statistical analysis is based on the Linear Structural Relations (LISREL) approach, which can be used in cases of causal modelling in non-experimental research (Saris & Stronkhorst, 1984). EQS is a programme for Structural Equation Modelling in accordance with the LISREL approach. By means of EQS, complex regression and factor models can be tested. It estimates parameters by using the covariance (correlation) matrix of selected variables (Bentler, 1989). A model based on a theory or a set of hypotheses can be specified and tested against the data, and a series of equations can be tested simultaneously. Constraints can also be imposed upon the data and correlated errors can be specified, but this was not necessary for our model. The model fit, the fit between the specified model and the data, can be tested by means of a fit index and a X^2 statistic. According to the method, the model fits perfectly in case of a Bentler-Bonett normed fit index of 1, while the X^2 should approximate the degrees of freedom *df*.

In the case of our model the number of cases was 49, while the data concerned aggregated variables over a period of one crop cycle in respect of cultivation data, one year in respect of livestock data and one observation in respect of price data. Although the model does not use longitudinal data, it can be considered a causal model, as is normally the case with economic models. The values of the coefficients should, however, be handled with care because of the relatively small number of cases. The significance of the various paths is more important than the values of the coefficients.

The correlation matrix of the variables was:

	V1	V2	V3	V4	V5	V6	V7	V8
V1	1.000							
V2	0.484	1.000						
V3	0.491	0.712	1.000					
V4	0.268	0.268	0.150	1.000				
V5	0.333	0.413	0.400	0.399	1.000			
V6	-0.102	0.145	0.228	0.178	0.273	1.000		
V7	-0.340	-0.023	-0.101	-0.116	-0.068	0.280	1.000	
V8	0.402	0.368	0.570	0.122	0.115	-0.029	-0.154	1.000

Explanation of the variables: V1= area under potatoes (acres/household); V2= cash out of milk sales (KSh/household); V3= no of (up)graded cows (cows/household); V4= selling price (KSh/bag); V5= average potato harvest per household in the sub-location (bags); V6= yield (bags/acre); V7= level of fertilizer applications (KSh/acre); V8= size of the holding (acres)

The model that was fed into the EQS programme was based on multiple regression analysis with step-wise elimination. The results of the LISREL analysis were as follows:

ln (gross potato income) = ln (potato harvest) + ln (selling price)

ln (potato harvest) = ln (acres under potatoes) + ln (yield per acre)

ln (acres under potatoes) = 0.48 * ln (cash out of milk sales) - 0.33 * ln (fert applications per acre) + E1
(t=4.1) (t=-2.8)

ln (yield per acre) = 0.26 *ln (no of (up)graded cows) + 0.31 * ln (fertilizer applications per acre) + E2
(t=2.0) (t=-2.3)

ln (cash out of milk sales) = 0.71 * ln (no of (up)graded cows) + E4
(t=7.0)

ln (no of (up)graded cows)= 0.57 * ln (size holding) + E5
(t=4.8)

ln (selling price) = 0.40 * ln (average potato production in the sub-location) + E3
(t=3.0)

ln (average potato production in the sub-location) = 0.34 * ln (potato harvest) + E6
(t=3.7)

The model fits substantially: X^2(df=20)=16.7; p=0.67; Bentler-Bonnet normed fit index= 0.856. The standardized solution of the model is:

ln (gross potato income) = 0.75 * ln (potato harvest) + 0.53 * ln (selling price)

ln (potato harvest) = 0.71 * ln (acres under potatoes) + 0.72 * ln (yield per acre)

ln (acres under potatoes)= 0.48*ln (cash out of milk sales) - 0.33*ln (fert applications per acre) + 0.81*E1

ln (yield per acre) = 0.26 *ln (no of (up)graded cows) + 0.30 * ln (fert applications per acre) + 0.92 * E2

ln (selling price) = 0.40 * ln (average potato production in the sub-location) + 0.92 * E3

ln (cash out of milk sales) = 0.71 * ln (no of (up)graded cows) + 0.70 * E4

ln (no of (up)graded cows)= 0.57 * ln (size holding) + 0.82 * E5

ln (average potato production in the sub-location) = 0.47 * ln (potato harvest) + 0.88 * E6

Appendix 22. Households with fruit trees and average number of fruit trees per owner by cluster, 1990

	UH1+2 zone												*UH3 zone*								*all zones*	
	Sabugo		*Melangine*		*Tulaga*		*Njabini*		*Geta*		*average*		*Kahuru*		*Karati*		*Mukeu*		*average*		*average*	
	(n=30)		*(n=30)*		*(n=30)*		*(n=30)*		*(n=30)*		*(n=150)*		*(n=30)*		*(n=30)*		*(n=30)*		*(n=90)*		*(n=240)*	
	%	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*	*%*	*no*
plums	73	42	67	45	70	10	87	16	83	33	76	29	63	29	67	11	76	12	69	17	73	24
pears	27	28	20	10	30	4	67	14	27	19	34	15	30	13	17	5	60	18	36	14	35	15
apples	0	0	0	0	0	0	0	0	17	82	3	82	7	30	3	4	0	0	3	21	3	59
peaches	0	0	0	0	0	0	3	6	0	0	1	6	0	0	0	0	0	0	0	0	0	0
treetomatoes	3	2	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
loquats	0	0	0	0	0	0	0	0	0	0	0	0	3	7	0	0	0	0	1	7	0	0

Source: farm survey, 1990

Note: except for apples only full-grown trees were counted.

Appendix 23. Average net fruit (cash) income by cluster, 1990 (KSh/household)											
	UH1+2 zone						*UH3 zone*				*all zones*
	Sabugo	*Melangine*	*Tulaga*	*Njabini*	*Geta*	*average*	*Kahuru*	*Karati*	*Mukeu*	*average*	*average*
	(n=30)	*(n=30)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=150)*	*(n=30)*	*(n=30)*	*(n=30)*	*(n=90)*	*(n=240)*
plums	416	324	12	24	524	259	3	24	53	27	172
pears	677	85	0	26	50	168	0	0	14	5	107
apples	0	0	0	0	33	7	0	0	0	0	4
peaches	0	0	0	0	0	0	0	0	0	0	0
treetomatoes	0	0	0	0	0	0	0	0	0	0	0
loquats	0	0	0	0	0	0	0	0	0	0	0
all fruits	1093	409	12	50	607	434	3	24	67	32	283
Source: farm survey, 1990											
Note: the total and cash income are defined as equal.											

Appendix 24. Hired labour, tractor services and family labour inputs for potatoes per acre, 1990													
	a	b	c	d	e	f	g	h	i	j	k	l	m
	cost hired labour									cost	total la-	total	total
	----------casual labour----------							per-	total	tractor	bour days	labour	value
	nr of	daily	nr of	daily	total	contract work		manent	cost	services	required	costs	household
	man-	wage	wo-	wage	daily	total	total	labour	hired	(KSh)	(incl.	(KSh)	labour
	days	men	man	women	wages	men	women	(KSh)	labour		household		(KSh)
		(KSh)	days	(KSh)	(KSh)	(KSh)	(KSh)		(KSh)		labour)*		
land prepa-													
ration, sowing	2.3	31	2.7	30	152	24	0	28	204	225	25	760	331
weeding,													
earthing up	0.4	31	3.0	31	105	0	0	25	130	0	20	620	490
spraying	0	-	0	-	0	0	0	7	7	0	4	124	117
harvesting,													
packing	0.5	33	2.2	30	83	0	0	77	160	0	26	799	639
total					340	24	0	137	501	225	75	2303	1577
Sources: columns a to j are based on the farm survey; column k is based on knowledge of agricultural extension officers of Nyandarua and MOA, 1989a; column l is calculated by multiplying the figures from column k with a weighted daily wage per activity (columns b and d); column m is calculated by deducting the cost of hired labour (column i) and tractor services (column j) from the total costs (column l).													

Appendix 25. Hired labour, tractor services and family labour inputs for cabbages per acre, 1990													
	a	b	c	d	e	f	g	h	i	j	k	l	m
	cost hired labour									cost	total la-	total	total
	----------casual labour----------							per-	total	tractor	bour days	labour	value
	nr of	daily	nr of	daily	total	contract work		manent	cost	services	required	costs	household
	man-	wage	wo-	wage	daily	total	total	labour	hired	(KSh)	(incl.	(KSh)	labour
	days	men	man	women	wages	men	women	(KSh)	labour		household		(KSh)
		(KSh)	days	(KSh)	(KSh)	(KSh)	(KSh)		(KSh)		labour)*		
land prepa-													
ration, nursery													
work, transpl.	0.9	36	2.6	30	110	15	13	60	198	195	25	786	393
weeding	1.1	33	2.5	32	116	0	0	60	176	0	20	644	468
spraying	0	-	0	-	0	0	0	12	12	0	4	124	112
harvesting,													
packing	0.1	40	0.3	35	15	0	0	60	75	0	20	640	565
total					241	15	13	192	461	195	69	2194	1538
Sources: columns a to j are based on the farm survey; column k is based on knowledge of agricultural extension officers of Nyandarua and MOA, 1989a; column l is calculated by multiplying the figures from column k with a weighted daily wage per activity (columns b and d); column m is calculated by deducting the cost of hired labour (column i) and tractor services (column j) from the total costs (column l).													

Appendix 26. Hired labour, tractor services and family labour inputs for spring onions per acre, 1990													
	a	b	c	d	e	f	g	h	i	j	k	l	m
	cost hired labour									cost	total la-	total	total
	----------casual labour----------							per-	total	tractor	bour days	labour	value
	nr of	daily	nr of	daily	total	contract work		manent	cost	services	required	costs	household
	man-	wage	wo-	wage	daily	total	total	labour	hired	(KSh)	(incl.	(KSh)	labour
	days	men	man	women	wages	men	women	(KSh)	labour		household		(KSh)
		(KSh)	days	(KSh)	(KSh)	(KSh)	(KSh)		(KSh)		labour)*		
land prepa-													
ration, sowing	0	-	4.8	23	110	20	9	23	162	0	24	552	390
weeding	0	-	0.9	23	21	0	0	23	44	0	14	322	278
spraying	0	-	0	-	0	0	0	0	0	0	0	0	0
harvesting,													
packing	0.5	25	0	-	13	0	0	24	37	0	20	500	463
total					144	20	9	70	243	0	58	1374	1131

Sources: columns a to j are based on the farm survey; column k is based on knowledge of agricultural extension officers of Nyandarua and MOA, 1989a; column l is calculated by multiplying the figures from column k with a weighted daily wage per activity (columns b and d); column m is calculated by deducting the cost of hired labour (column i) and tractor services (column j) from the total costs (column l).

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