SMALL SCALE DAIRYING IN THREE FARMING SYSTEMS IN EAST JAVA
I. FARMER'S INCOME AND HOUSEHOLD CHARACTERISTICS

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Summary

The annual income (gross margin) in 1989/90 of a sample of 274 farmers in seven milk cooperatives was analyzed in the sugar cane, cassava, and horticulture areas in East Java. On average dairying contributed 42%, crops 29% and off-farm revenue 29%. Dairy income was highest in the cassava area, where it compensated for the low crop income, and lowest in the sugar cane area. Farm area and average milk yield per day per cow correlated positively with farmer's income, whereas crop income increased significantly with farm area and with the number of cows. The level of total cost per cow had a negative impact on dairy and on total income. Government officials and other professionals engaged in dairying had a significantly higher total income than those with their main occupation in dairying, cropping or working as farm labourers. Uneducated farmers obtained a significantly larger income through crops, whereas farmers with tertiary education obtained more income through off-farm work. This study suggests that more attention must be paid to the actual use of labour and the improvement of the dairy output/cost ratio.

(Key Words : Dairying, Farmer's Income, Farming System, Indonesia)

Introduction

Dairy farming is being encouraged in Indonesia, to supply a product of high nutritional value, to generate income for farmers and to benefit from diversification. The Government of Indonesia has imported and distributed dairy cattle to villages to achieve this. The programme also aims to reduce migration to towns and cities, and to use the country's natural resources more efficiently. In addition, satisfying more of the national demand by domestic dairy products means that less foreign exchange will be needed to import milk and milk products.

Indonesia has old nuclei of dairying introduced by the Dutch government. More recently new nuclei of dairying have been introduced by the Government of Indonesia through special credit packages. Since 1980 Holstein Friesians have been imported, mostly from Australia, New Zealand, the United States and Japan.

To reduce expenditure on feed, Indonesian farmers use agricultural residues and by-products. Atmadilaga (1973) coined the term 'flying herd' since in Java dairy cattle have very few 'landing areas' because of the small farm sizes and limited capital in the rural area. The husbandry system followed is mainly zero-grazing. According to Kiura and Mangachi (1992), it is expected that zero-grazing enables smallholders to achieve high milk yields per animal and good economic returns from milk. And, to reduce the high expenditure of hired labour, farmers can enlist family help in dairying.

Three farming systems can be distinguished in East Java: sugar cane, cassava and horticulture oriented. In farming systems, crops and livestock are interdependent elements (Amir and Knipscheer, 1989). Farmer's income may be increased by utilizing the production factors for the combination of crops and dairying. Income may be augmented further with revenue from off-farm work.

In this study we aimed to analyse in part I. Farmer's income from dairying in relation to crop and off-farm work in three farming systems and to the household characteristics (age, edu-

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cation, main job, number of family members, and the farm area). More detailed economics and prospects of dairying were studied in part 2. Economic analysis of dairying.

Materials and Methods

East Java, the eastern part of Java island is 47,922 km² in area, has over 33 million inhabitants (1990) and is known for a higher livestock density compared with the other, wetter parts of Java (Ibrahim et al., 1991). The climate in East Java is tropical with average maximum and minimum temperatures of 32.4 and 24.3°C, respectively. In the highlands, 400 m and more above sea level, these temperatures are much lower on average. There is one rainy season from December to May with rainfall varying from 140-720 mm per month and the dry season lasts from July to November with 10-85 mm per month (Statistical Yearbook of Indonesia, 1979). Some villages have Grati cattle, which originated from crossing local cattle with Dutch Friesians. They were developed in the Grati district (Widodo et al., 1980).

Javanese dairy farmers feed their cattle grass and certain crop residues, i.e. sugar cane tops, rice straw, maize stover or other by-products such as rice bran and coconut meal. The farmers grow crops and vegetables on the limited arable land for human consumption and use the by-products for animal feed.

In our study we focused on seven of the 66 dairy cooperatives in East Java, representing various combinations of old and new dairy nuclei and farming systems:

1. Malang, an old dairy nucleus with horticulture
2. Pasuruan, an old dairy nucleus with sugar cane
3. Jombang, an old dairy nucleus with horticulture
4. Mojokerto, a new dairy nucleus with horticulture
5. Kediri, a new dairy nucleus with sugar cane
6. Blitar, a new dairy nucleus with cassava
7. Tulungagung, a new dairy nucleus with cassava.

In the horticultural area (over 400 m above sea level) the temperatures are less extreme and temperate crops can be grown, mainly vegetables such as cabbage, potatoes and carrots. In the sugar cane area (0-150 m above sea level) the climate is hot and humid and the land is cultivated on contract with sugar cane. In the cassava area, situated in the more marginal lowland between 100 and 400 m above sea level, the climate is hot and relatively dry.

Out of the main dairy regions in East Java we selected one location typical of the farming system in the region, and per milk cooperative we selected two villages (one far and one near the milk cooperative buildings). In each village we took a minimum of 15 households/members of the milk cooperative at random as respondents with at least two years' experience in dairying. The actual number of households surveyed was 274.

Data were collected by interviewing the farmers using a questionnaire on the family background, land use, dairy husbandry, and aspects of the farmer's income over the year 1989/90. The procedures were as follows:

- data collection was related to a whole year preceding the survey (June, 1990) and the market price in 1990 in Indonesian Rupiah (1 US $ = Rp 1,900)
- the educational background of the heads of the households was classified into 5 classes: uneducated; elementary school; junior high school; senior high school; tertiary level
- the main job or occupation in time of the heads of the households was classified in: dairy farmer; crop farmer; labourer; government official; other profession
- the experience in dairying and the age of the head of the household was recorded in years (y)
- the family size was recorded in persons (n)
- the farm area or farm size was taken from the Government letter indicating the land area of the farmer (m^2)
- the lactation length, calving interval, period between calving and first service post-partum of the dairy cows were obtained in days
- the average milk production was calculated from the indicated months of high and low production and the respective yields in litres per day per cow (l/d/cow)
- the total milk sold by the farmer was taken from the records of the milk cooperatives in litres per year (l)

– the dairy animals were categorized in number (and TLU) of female and male calves (0.2 TLU each), heifers and steers (0.8 TLU), dairy cows (1.2 TLU) and bulls (1.4 TLU) whereby one TLU stands for a tropical livestock unit, i.e. a dairy animal of 350 kg

– the livestock density was calculated in TLU per hectare (TLU/ha)

– farmer's total annual income (gross margin) was estimated by enquiring about crop income, off-farm income and dairy income in rupiah (Rp)

– the income from crops was obtained by subtracting the expenses of production from the revenues from crops (Rp)

– off-farm income was calculated from revenues received (Rp)

– the income or gross margin in dairying was calculated as cash revenues minus costs for feeds, animal health, breeding and hired labour (Rp)

– the cash output or gross income from dairying was calculated from the sales of milk, manure, male and female animals and proceeds from draught power

– the capital investment in dairying was obtained from the value of the cowshed, equipment and animals (Rp)

– the cash inputs of dairying were composed of hired labour, bought in rice bran, coconut meal and feed additives, and the expenditure on animal health and breeding. The roughage costs were estimated from the quantities used and the value in the respective area and season. Cash inputs and roughage costs formed the variable dairy costs (Rp)

– the total costs were calculated as the variable costs plus the fixed costs. For the latter, depreciation of cattle housing was calculated at 10%, and the equipment was depreciated at 20 %. The cost of interest was calculated at 18% over half of the investment in shed, equipment and animals. The latter was taken at Rp 1,000 ,000 per TLU, based on the average between the purchase value of one cow (1.2 TLU) at Rp 1,700,000 and the culling value of Rp 700,000

– the dairy output/cost ratio was calculated as cash output divided by total costs of dairying (Rp)

The data were analyzed with DbStat (Brouwer, 1992). Least square methods were used to explain variations in farmer's total annual income, dairy income, crop income and off farm income in relation to the differences in farm and family resources. The following models were tested:

1. the farmer's total annual income :

$$Y_{IJkf} = m + FS_i + EB_j + MJ_k + b_1x_{1f} + b_2x_{2f} + b_3x_{3f} + b_4x_{4f} + b_5x_{5f} + b_6x_{6f} + b_7x_{7f} - b_8x_{8f} + E1_{IJkf}$$

2. the annual dairy income :

$$Y_{IJkd} = n + FS_i + EB_j + MJ_k + b_1x_{1d} + b_2x_{2d} + b_3x_{3d} + b_4x_{4d} + b_5x_{5d} + b_6x_{6d} + b_7x_{7d} + b_8x_{8d} + E2_{IJkd}$$

3. the annual crop income :

$$Y_{IJkc} = o + FS_i + EB_j + MJ_k + b_1x_{1c} + b_2x_{2c} + b_3x_{3c} + b_4x_{4c} + b_5x_{5c} + b_6x_{3c} + b_7x_{7c} + b_8x_{8c} + E3_{IJkc}$$

4. the annual off-farm income :

$$Y_{IJko} = p + FS_i + EB_j + MJ_k + b_1x_{1o} + b_2x_{2o} + b_3x_{3o} + b_4x_{4o} + b_5x_{5o} + b_6x_{6o} + b_7x_{7o} + b_8x_{8o} + E4_{IJko}$$

Y_{IJkf} = farmer's total annual income (Rp)
Y_{IJkd} = annual dairy income (Rp)
Y_{IJkc} = annual crop income (Rp)
Y_{IJko} = annual off-farm income (Rp)
FS_i = farming system area,
i = 1, 2, 3 (sugar cane area; cassava area; horticultural area)
EB_j = educational background of the household head.
j = 1, 2, 3, 4, 5 (uneducated; elementary school; junior high school; senior high school; tertiary level)
MJ_k = main job of the household head.
k = 1, 2, 3, 4, 5 (dairy farmer; crop farmer; labourer; government official; other profession)

The following covariables were adjusted for their average :

$x_{1f,d,c,o}$ = family members (n).
$x_{2f,d,c,o}$ = dairy experience (y).
$x_{3f,d,c,o}$ = farm area (m^2).
$x_{4f,d,c,o}$ = dairy cow (n).
$x_{5f,d,c,o}$ = average milk yield in litres per day per cow (l/d/cow).
$x_{6f,d,c,o}$ = livestock density (TLU/ha).
$x_{7f,d,c,o}$ = total cost per dairy cow (per 000Rp).
$x_{8f,d,c,o}$ = other dairy stock (young stock, bull) in TLU
m,n,o,p = overall average

$b_{1..9}$ = regression coefficient
$E1_{ijkl} \cdot \cdot E4_{ijko}$ = residual term

Results

Figure 1 presents a breakdown of the average income (gross margin) of the East Javanese dairy farmers surveyed. The breakdown of the average income was: 42% dairy income, 29% crop income and 29% off-farm income. Table 1 gives the means and the coefficients of variation for data collected and calculated from the 274 respondents of the seven Milk Cooperatives in the three farming systems.

The average age of the household heads in East Java varied from 37 in the sugar cane area to 43 years in the horticultural area. The average dairying experience differed similarly, 3.7 versus

TABLE 1. MEANS AND COEFFICIENTS OF VARIATION (C.V.) FOR SELECTED VARIABLES OF "SMALL SCALE DAIRYING IN THREE FARMING SYSTEMS IN EAST JAVA, INDONESIA"

Variables	Sugar cane area		Cassava area		Horticulture area		Overall	
	Means	c.v.	Means	c.v.	Means	c.v.	Means	c.v.
No. of households	80		82		112		274	
Age household head (y)	37	0.27	41	0.31	43	0.29	42	0.30
Family members (n)	4.3	0.35	4.3	0.39	4.9	0.37	4.5	0.38
Dairy experience (y)	3.7	0.62	4.3	0.67	5.2	0.66	4.5	0.68
Farm area (ha)	0.48	1.05	0.37	1.41	0.80	1.01	0.58	1.17
Dairy cows (n)	2.15	0.55	2.52	0.65	2.26	0.64	2.31	0.63
Total animals (TLU)	3.16	0.54	3.64	0.63	3.17	0.58	3.31	0.59
Density (TLU/ha)	53.7	2.09	75.7	1.60	25.9	2.68	48.7	2.08
Post partum to first service (days)	93	0.16	83	0.30	87	0.50	87	0.36
Calving interval (d)	425.6	0.12	415.3	0.18	379.6	0.45	403.7	0.30
Average yield (l/d/cow)	10.4	0.62	11.0	0.29	10.7	0.32	10.7	0.30
Lactation length (d)	350.8	0.17	315.1	0.16	309.5	0.18	323.2	0.18
Annual total farmer's income (000 Rp)	1,185	1.14	1,391	0.75	1,664	1.05	1,443	1.01
Crop income	491	1.75	227	1.24	491	1.70	412	1.77
Off-farm income	350	1.56	359	1.84	523	2.39	424	2.19
Gross margin dairy	344	2.25	805	1.01	650	1.42	607	1.43
Crop income (%)	41		16		30		29	
Off-farm income (%)	30		26		31		29	
Gross margin dairy (%)	29		58		39		42	
Dairy activities								
Revenues (000 Rp)	2,280	0.63	2,688	0.57	2,189	0.54	2,365	0.59
Variable cost (000 Rp)	1,936	0.54	1,884	0.61	1,538	0.49	1,758	0.56
Fixed cost (000 Rp)	646	0.51	725	0.61	646	0.56	670	0.57
Total cost/ dairy cow (000 Rp)	1,262	0.25	1,086	0.24	1,052	0.35	1,123	0.30
Output/cost ratio	0.88		1.03		1.00		0.97	

N.B.> Sugar cane area: Pasuruan and Kediri Milk Cooperatives.
Cassava area: Blitar and Tulungagung Milk Cooperatives
Horticulture area: Malang, Jombang and Mojokerto Milk Cooperatives.

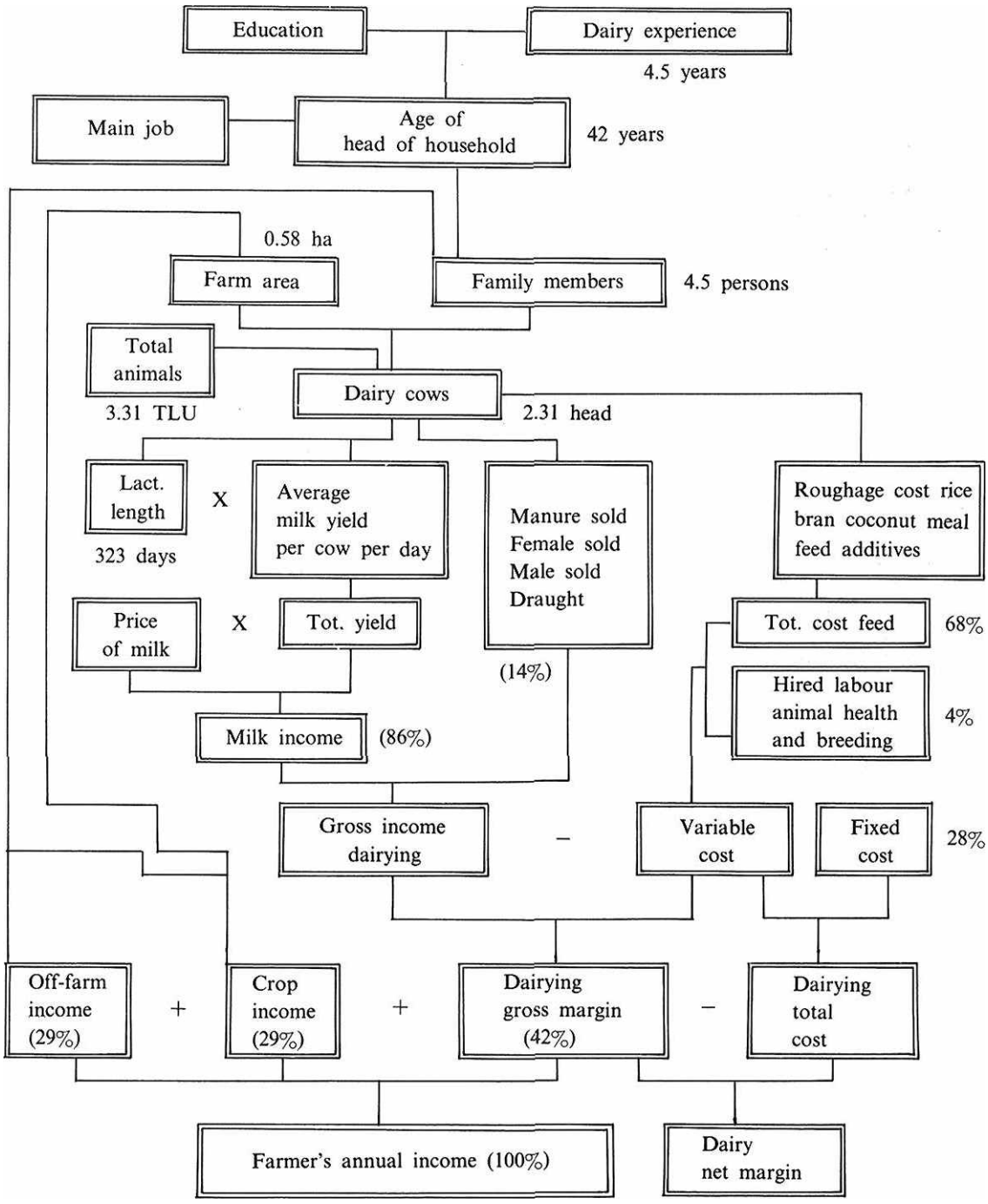

Figure 1. Breakdown of the average income of the dairy farmers surveyed in East Java, Indonesia.

5.2 years and the family size was 4.3 versus 4.9 persons. The area farmed was smallest in the cassava area (0.37 hectares) and largest (0.80 hectares) in the horticultural area. All these parameters had extremely large coefficients of variation. The dairy cattle per farm varied from 3.2 TLU in the sugar cane area to 3.6 TLU in the cassava area and the number of dairy cows

from 2.2 to 2.5, respectively.

The farmer's total annual income was the lowest in the sugar cane area being Rp 1,185,000 compared with Rp 1,391,000 in the cassava area and Rp 1,664,000 in the horticultural area. The relative contribution of crops, dairying and off-farm work differed considerably per area.

The total cost per dairy cow was the highest in the sugar cane area being Rp 1,262,000 per head compared with Rp 1,086,000 per head in the cassava area and Rp 1,052,000 per head in the horticultural area. The dairy output/cost ratio was very low in all areas.

The very large coefficients of variation of the farmer's total annual income (table 1) indicate that the three farming systems were not very homogenous for the variables selected. In table 2, the variation in farmer's total annual income is analyzed by least square methods. So, each component of the model is adjusted for the other components. There was no statistically significant difference in farmer's income between farming systems, but there were very statistically significant differences ($p<0.001$) related to the main job and the educational background of the farmers. Government officials and other professionals

TABLE 2. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM PARAMETERS WITH FARMER'S TOTAL ANNUAL INCOME (000 RUPIAH) AS DEPENDENT VARIABLE FOR THE 80 RESPONDENTS IN THE SUGAR CANE AREA, 82 IN THE CASSAVA AREA AND 112 IN THE HORTICULTURAL AREA

Factors	l.s. mean	s.e.[1]	Regr. coef.	s.e.[1]
Overall average	1,802	128		
Farming system:				
– Sugar cane area	1,681	179		
– Cassava area	1,822	176		
– Horticultural area	1,902	161		
Educational background:				
– Uneducated	1,922^{ab}	322		
– Elementary school	1,723^{a}	179		
– Junior high school	1,770^{a}	131		
– Senior high school	1,325^{a}	299		
– Tertiary	2,270^{b}	274		
Main job:				
– Dairy farmer	1,603^{a}	239		
– Crop farmer	1,197^{a}	132		
– Labourer	1,149^{a}	270		
– Government official	2,568^{b}	251		
– Other profession	2,493^{b}	349		
Family members (n)			84.20	44.91
Dairy experiences (y)			61.29	57.18
Farm area (ha)			551.65***	126.43
Dairy cows (n)			−34.50	64.61
Other dairy stock (TLU)			334.94*	130.49
Milk average (l/d/cow)			126.26***	24.76
Livestock density (TLU/ha)			−0.22	0.93
Total cost per dairy cow (per 000 Rp)			−0.576*	0.278
R^2 full model[2]: 36%				

[1] Standard error.

[2] Coefficient of determination.

l.s. Means with different superscripts are statistically significantly different ($p < 0.001$); * $p < 0.05$, *** $p < 0.001$.

earned more than crop farmers, dairy farmers and labourers. Farmers with tertiary education had a higher total income than less educated farmers. The magnitude of the regression coefficients indicates how much the farmer's total annual income increases or decreases in response to deviations from the average of specific farm resources.

The greatest sources of variation in farmer's total annual income were farm area ($p<0.001$), the average milk yield ($p < 0.001$), and the number of dairy stock other than cows ($p < 0.05$). An increase in farm area by one hectare was estimated to contribute Rp 551,650 to the mean farmer's total annual income of Rp 1,802,000. An increased average milk yield of one litre per day per cow would contribute Rp 126,260 and dairy stock other than cows per TLU Rp 334,940.

The larger than average family size would increase the annual total farmer's income by Rp 84,200 per additional member but the difference was not statistically significant. A similar small increase was found for an extra one year of dairy experience (Rp 61,290). The total cost of dairying per cow decreased significantly the farmer's total annual income. The coefficient of determination

TABLE 3. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM PARAMETERS WITH ANNUAL INCOME DAIRY (000 RUPIAH) AS DEPENDENT VARIABLE FOR THE 80 RESPONDENTS IN THE SUGAR CANE AREA, 82 IN THE CASSAVA AREA AND 112 IN THE HORTICULTURAL AREA

Factors	l.s. mean	s.e.[1]	Regr. coef.	s.e.[1]
Overall average	626	81		
Farming system:				
– Sugar cane area	415[a]	114		
– Cassava area	807[b]	112		
– Horticultural area	656[b]	105		
Educational background:				
– Uneducated	546	205		
– Elementary school	682	115		
– Junior high school	686	83		
– Senior high school	559	191		
– Tertiary	659	175		
Main job:				
– Dairy farmer	699[a]	152		
– Crop farmer	531[a]	84		
– Labourer	384[b]	172		
– Government official	565[a]	160		
– Other profession	953[a]	222		
Family members (n)			5.46	28.66
Dairy experience (y)			24.15	36.49
Farm area (ha)			−46.09	80.68
Dairy cows (n)			−58.47	41.23
Other dairy stock (TLU)			170.71*	83.27
Milk average (l/d/cow)			116.96***	15.80
Livestock density (TLU/ha)			0.345	0.591
Total cost per dairy cow (per 000 Rp)			−0.422*	0.177
R^2 full model[2]: 25%				

[1] Standard error.

[2] Coefficient of determination.

l.s. Means with different superscripts are statistically significantly different ($p < 0.05$): * $p < 0.05$, *** $p < 0.001$.

(R^2 = 36%) was small.

Table 3 gives a similar analysis for the annual dairy income. The variables selected explained only a small part of the variation (R^2 = 25%). The dairy income in the sugar cane area was statistically significantly lower ($p < 0.05$) than in the other two areas. There were no statistically significant differences between levels of education, but labourers obtained significantly less ($p < 0.05$) than the ones with another main job. The greatest source of variation was the average milk yield per cow ($p < 0.001$). The corrected mean for annual dairy income was Rp 626,000. An increase in average milk yield of one litre was estimated to boost annual dairy income by Rp 116,960, while extra other dairy stock would do so by Rp 170,710 per extra TLU ($p < 0.05$). The years of dairying experience of the head of the household, the number of family members and the livestock density had a positive impact but did not contribute significantly to the annual dairy income. The number of cows and the farm area had a negative impact but only the total cost per cow reduced the dairy income significantly. Neither extra cows nor improved calving intervals, above the average levels in this study,

TABLE 4. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM PARAMETERS WITH ANNUAL CROP INCOME (000 RUPIAH) AS DEPENDENT VARIABLE FOR THE 80 RESPONDENTS IN THE SUGAR CANE AREA, 82 IN THE CASSAVA AREA AND 112 IN THE HORTICULTURAL AREA

Factors	l.s. mean	s.e.[1]	Regr. coef.	s.e.[1]
Overall average	437	68		
Farming systems:				
– Sugar cane area	566[a]	94		
– Cassava area	360[b]	93		
– Horticultural area	385[ab]	87		
Educational background:				
– Uneducated	688[a]	170		
– Elementary school	319[b]	95		
– Junior high school	451[b]	69		
– Senior high school	289[b]	158		
– Tertiary	438[b]	145		
Main job:				
– Dairy farmer	612	126		
– Crop farmer	415	70		
– Labourer	405	142		
– Government official	375	133		
– Other profession	378	184		
Family members (n)			17.81	23.75
Dairy experience (y)			50.90	30.24
Farm area (ha)			429.00***	66.86
Dairy cows (n)			79.57*	34.17
Other dairy stock (TLU)			−21.57	69.01
Milk average (l/d/cow)			−7.71	13.09
Livestock density (TLU/ha)			−0.996*	0.490
Total cost per dairy cow (per 000 Rp)			0.074	0.147
R^2 full model[2]: 27%				

[1] Standard error.

[2] Coefficient of determination.

l.s. Means with different superscripts are statistically significantly different ($p < 0.05$); * $p < 0.05$, *** $p < 0.001$.

contributed statistically significantly to more income from dairying.

The annual income from crops (table 4) in the sugar cane area was statistically significantly higher than in the cassava area ($p < 0.05$). No statistically significant differences were found for the main job of the farmer, but uneducated farmers had significantly more crop income than the ones with education.

The greatest source of variation in annual crop income was farm area ($p < 0.001$), with Rp 429,000 for an extra hectare on top of the corrected mean of the annual crop income of Rp 437,000 for 0.58 hectares. The number of dairy cows also had a positive impact ($p < 0.05$) on annual crop income (Rp 79,570 per cow above average). Livestock density had, however, a negative and statistically significant impact ($p < 0.05$) of Rp 996 per extra TLU per ha above the average livestock density on annual crop income.

In table 5 the least squares analysis shows statistically significant differences in off-farm income for the educational level and the main job of the household head. Farmers with tertiary education, government employment or employment

TABLE 5. LEAST SQUARES MEANS AND REGRESSION COEFFICIENTS FOR VARIOUS FARM PARAMETERS *WITH ANNUAL OFF-FARM INCOME (000 RUPIAH) AS DEPENDENT VARIABLE FOR THE 80 RESPONDENTS IN THE SUGAR CANE AREA, 82 IN THE CASSAVA AREA AND 112 IN THE HORTICULTURAL AREA*

Factors	l.s. mean	s.e.[1]	Regr. coef.	s.e.[1]
Overall average	738	81		
Farming systems:				
– Sugar cane area	700	114		
Cassava area	654	112		
– Horticultural area	861	105		
Educational background:				
– Uneducated	687[a]	205		
– Elementary school	721[a]	114		
– Junior high school	632[a]	83		
– Senior high school	477[a]	191		
– Tertiary	1,173[b]	175		
Main job:				
– Dairy farmer	291[a]	152		
– Crop farmer	251[a]	84		
– Labourer	359[a]	171		
– Government official	1,628[b]	160		
– Other profession	1,163[b]	222		
Family members (n)			60.94*	28.64
Dairy experience (y)			13.75	36.47
Farm area (ha)			168.74*	80.63
Dairy cows (n)			−55.60	41.21
Other dairy stock (TLU)			185.80*	83.22
Milk average (l/d/cow)			17.01	15.79
Livestock density (TLU/ha)			0.873	0.591
Total cost per dairy cow (per 000Rp/head)			−0.227	0.117
R^2 full model[2]: 34%				

[1] Standard error.

[2] Coefficient of determination.

l.s. Means with different superscripts are statistically significantly different ($p < 0.05$) for education. ($p < 0.01$) for main job. * $p < 0.05$.

in other rural professions did have a larger off-farm income. Larger than average families could earn statistically significantly more off farm income but only at the rate of Rp 60,940 per extra member. Surprisingly a larger than average farm area as well as keeping more dairy stock, other than cows, than average in the survey was associated with more off-farm income.

Discussion

The analysis of farmer's total income revealed no statistically significant differences between the three areas, although the crop income was statistically significantly higher in the sugar cane area, whereas the dairy income was highest in the cassava area, because here there were more cows.

In the cassava area the climate is drier and the land is susceptible to erosion during the rains. Crop production is low and farmers manage to compensate for this through dairy production. In the sugar cane area, the annual dairy income was smallest, but was compensated for by a high annual crop income from contracted sugar cane production. This may be due to the fact that farmers first opt for activities with a more guaranteed income to avoid risk (Amir and Knipscheer, 1989). The farmers in the horticultural area received the highest income per farm and this was obtained almost equally from crops, off-farm work and dairying. However, the per ha income from crops and dairying was only Rp 1,328,000 in the horticultural area compared with Rp 1,5 03,000 in the sugar cane area and Rp 2,41 1,000 in the cassava area. This suggests that in the horticultural area there is insufficient family labour for more intensive use of the land. Further research needs to be done on the seasonality and use of labour applied in the various activities in the three systems.

Farm area had a statistically significant effect on the farmer's total annual income and crop income but not on dairy income. So, farm area is a major factor (capital) in cropping but not in dairying in the rural areas we studied. Sayogyo (1976) found that 54% of the farmers in Java had less than 0.5 ha of land in 1963. This percentage has since increased because of the increasing population pressure. In the prevailing inheritance system land is divided among all family members and is split into very small plots (=warisan); some families have even become landless (Atmadilaga, 1992). The average farm area per household in this study was 0.58 ha, with a coefficient of variation of 1.17.

The educational level of the head of the household was only statistically significantly different for the tertiary level in relation to the farmer's total annual income based upon off-farm work, but not upon cropping or dairying. *Government employment and other professions* added significantly to farmer's total income, through off-farm income.

The crop income was statistically significantly higher for the uneducated heads of the households engaged in dairying (table 2). These uneducated farmers are usually the informal leaders of the villages with long experience in crop farming.

The number of dairy cows had a significant and positive effect on annual crop income. This could indicate the advantage of using manure and reducing the input of artificial fertilizer. This result confirmed previous research by Udo et al. (1992) in Bangladesh, which indicated that keeping cattle supported crop production. However, livestock density had a negative impact on crop income ($p < 0.05$), indicating that under present conditions a higher livestock density means competition with crop land although this is compensated for through extra income from extra dairy stock other than cows (table 3 and 4).

This study also indicated that the output/cost ratio in dairying, taken as cash outputs over the total of variable and fixed cost was very low (table 1). The farmers in East Java are currently finding it difficult to increase their net income by dairy farming and to pay back their loans in time (Widodo, 1991). The only remaining advantages of dairying are first: the attractive two-weekly payment system for milk compared with the income from crops which is received only per harvest (i.e. at best quarterly, depending on the crop planted), and second: the roughage cost in dairying means actual family income since the collection is mainly done from outside the own farm area and for about 80% by family labour. In part 2, the economics and prospects of dairying are further analysed in detail.

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