



Characteristics of small-scale dairy farms in Lembang, West-Java

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Summary: The increasing demand for dairy products in Indonesia may offer possibilities for dairy farmers to increase milk production, and improve their incomes and livelihoods. This study showed dairy farms in Lembang district, West-Java, are mostly small-scale, zero-grazing dairy farms with high stocking densities per unit of land, and a milk production level and reproductive performance below potential. The scarcity and fragmentation of land are causing challenges of obtaining sufficient and good quality fodder and recycling of manure as a fertilizer. Results indicated there is room for improvement of feeding and manure management practices, which may not only contribute to improved farm productivity, but also to improved resource use efficiency and reduction of environmental impacts of dairy farming in Lembang district.

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The ISO 9001 certification by DNV underscores our quality level. All our research commissions are in line with the Terms and Conditions of the Animal Sciences Group. These are filed with the District Court of Zwolle.

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Key messages

Characteristics of dairy farms in Lembang district, West-Java, are:

- Small-scale, zero-grazing farms with an average herd consisting of 4 adult cows and 2 young stock, and an average milk production of 4415 kg milk per cow/year. Most farms (84%) have a small amount of land for production of fodder or food crops (0.3 ha per farm), with about half of the land being located >500m away from the cow barn;
- Most farmers have problems accessing sufficient green fodder during the dry season, and replace part of grass in the feed ration by rice straw and additional compound feed. Farmers do not feed lactating cows according to milk production level or lactation stage, and on part of the farms, cows do not have continuous access to drinking water;
- Most farms (84%) discharge at least part of the cattle manure to the environment. Less than half of the farms use manure for fertilization of fodder or food crops. Farmers do not utilize manure because of a lack of storage space on the farm, labour requirements, land being located far away, and difficulties of handling and transporting manure;
- Cutting and collecting grass is the most time consuming activity, taking more than 3 hours/day.

The situation in Lembang can lead to several challenges for dairy farms and the environment:

- The high stocking density and scarcity of land leads to challenges of obtaining sufficient and good quality fodder, and recycling of manure as a fertilizer;
- The fragmentation of land (i.e. land being scattered and located far away from the cow barn) causes collection of fodder to be time-consuming, adds to the challenge of recycling of manure as a fertilizer, and can enhance synthetic fertilizer use;
- Poor feeding practices and unbalanced feed rations can lead to sub-optimal milk production and reproductive performance, increased feed costs per kg milk, and increased greenhouse gas emission intensity.
- Discharging of cattle manure can cause local nuisance, a loss of valuable nutrients and organic matter, pollution of ground and surface water, and increased GHG emissions.

The variation in productivity and farming practices, however, indicates there is room for improving technical and environmental performance of dairy herds in Lembang district. Possible solutions are:

- A spatial development strategy for the dairy sector on Java, including a land consolidation policy (i.e. readjustment of land parcels);
- Optimizing grass yields to improve land use efficiency and optimal use of scarce land resources;
- Feeding a better quality conserved feed in the dry season (e.g. maize or grass silage), or improving the nutritional quality of rice straw;
- Balancing feed rations according to nutritional requirements of individual cows, and improvement in housing to facilitate continuous access to water;
- Reducing discharging of manure, and recycling manure as a fertilizer for feed and food production;
- Improving methods of transport and application of manure to optimize grass yields and avoid over-fertilization;
- Enhancing production of solid cattle manure (e.g. compost) for fertilization of land located further away from the barn or sales to the horticultural sector;
- Overall, improvements of feeding and manure management should contribute to 'sustainable intensification', which implies more is produced from the same resources while avoiding negative impacts on the environment.

1 Introduction

Milk consumption in Indonesia has risen sharply in the past decades, as a result of rising incomes, population growth, and urbanization. The increase in consumption of dairy products in South East Asia is expected to continue to grow in the coming decades (by 13% between 2017 and 2026; OECD/FAO, 2017). Besides this, whereas most of the milk processed by the dairy industry is currently imported from abroad, the Government of Indonesia aims to increase domestic milk production to about 40% of national industrial demand by 2021 in order to increase its self-sufficiency and reduce its dependency on imports.

The increase in demand for dairy products may offer possibilities for Indonesian dairy farmers to increase milk production, and improve their incomes and livelihoods. However, currently dairy production mostly takes place in small-scale dairy farms on Java island, with a productivity level well below potential. In the current situation, increasing milk production on farms is expected to be challenged by difficulties around feeding, reproduction, animal health, labor, and other farm management aspects. Besides this, waste management on dairy farms is currently poor, with manure causing local nuisance and pollution of water streams and rivers.

Dairy farming also contributes to emissions of greenhouse gases, leading to climate change. The Government of Indonesia committed itself to substantially reduce national greenhouse gas emissions in the coming decades, including emissions from agriculture. Hence, the increase in domestic milk production should be realized using low-emission techniques on dairy farms, to avoid increases in greenhouse gas emissions.

A better understanding of farming characteristics helps to identify barriers and opportunities for increasing milk production in a sustainable way. The objective of the present study, therefore, was to evaluate current characteristics of dairy farming in Lembang, West-Java. This study focused on herd performance, land use, feeding and manure management, and labor. Besides describing the general population, farms were compared based on land size, specialization, and gender aspects.

Results of this study serve as a basis for identification of feeding and manure management strategies for improved milk production and reduced greenhouse gas emissions in dairy farms in Lembang district (De Vries et al., in press).

2 Material and Methods

In November and December 2016, a baseline survey was conducted among 300 members of the dairy cooperative KPSBU Jabar in Lembang district, West-Java. KPSBU has nearly 4500 active member farmers and is a major supplier to Frisian Flag Indonesia (FFI). Information was collected on current herd composition and performance, land use, feeding practices, manure management practices, other farming practices, and farmers' perceptions and motivations. Specific attention was paid to the roles of women.

2.1 Herd selection

In October 2016, 300 dairy farms were randomly selected from the total list of 4361 dairy farms delivering milk to the dairy cooperative KPSBU Jabar in Lembang. To assure sufficient farms in the final sample, first 450 dairy farms were selected from the total list of dairy farms delivering milk to KPSBU Jabar, using simple random sampling. Farms were only included in the survey if they were delivering milk to KPSBU. Farmers were asked again if they still delivered milk to KPSBU Jabar short before the planned date of farm visit.

2.2 Farm visits

A questionnaire was developed by Wageningen Livestock Research, with input from Agricultural University IPB. Five enumerators of the University of Padjajaran (BSc students; UNPAD) were trained by WUR and UNPAD in a 5-day course, including two days of field testing of the questionnaire.

Enumerators collected data on 300 farms in November and December 2016, with an average of 3 interviews per enumerator per day, and the length of the survey ranging between 45 and 60 minutes per farm. Questions were in Bahasa, with translation to Sundanese on the spot when needed. Answers to the survey were administered on tablets.

2.3 Data analyses

Descriptive statistics were carried out to describe general characteristics of farms in the baseline survey. Farms were compared based on 3 characteristics: i) land size, ii) specialization (mixed crop-livestock versus specialized dairy farm), and iii) gender of the person in charge of the dairy farm:

- With regard to land size, farms were classified into the category landless when the amount of dry matter (DM) from fodder produced on the farm was less than 10% of the total dry matter intake of the herd (adapted from Seré and Steinfeld, 1995)¹. Otherwise, the farm was classified as land-based. As the most common fodder fed to dairy cattle in Lembang is King grass, the amount of on-farm produced fodder (DM) was estimated multiplying the total area

¹ In Sere and Steinfeld (1995), landless livestock production systems are defined as a subset of the solely livestock production systems in which less than 10% of the dry matter fed to animals is farm-produced and in which annual average stocking rates are above ten livestock units (LU) per hectare of agricultural land.

used for production of fodder and the average yield of King grass (i.e. about 15 ton DM/ha/year; personal comm. Mr. B. Wouters, 2017). DM intake of cattle was estimated at 3285 kg per livestock unit (LU)/year, assuming a daily DM intake of 2% of the body weight and an average body weight of 450 kg for adult cattle. Total DM intake of herds was estimated assuming 1 LU for adult cattle and 0.5 LU for young stock.

- With regard to specialization, mixed crop-livestock farms were defined as farms that produced crops, besides dairy products. Other farms were classified as specialized dairy farms.
- With regard to gender, a farm was assumed to be a female managed herd if a woman was in charge of the dairy farm.

Differences between categories were statistically tested using the Independent-Samples T Test for continuous variables and the Pearson Chi-Square test for categorical variables. Differences between the wet and the dry season were tested using the Paired-Samples T Test.

3 Results and discussion

Most of the 300 farms in the baseline survey were located in the villages Sukajaya and Cikahuripan. Farms included in the survey were related to 26 Milk Collection Points (MCPs) of the dairy cooperative KPSBU Jabar, with most farms related to the MCPs of Suntenjaya, Pojok, Cilumber, Manoko, and Cibedung.

In the following paragraphs results are shown of average herd composition and performance, land use, feeding, and manure management. In addition, the most important differences are shown for 3 types of farm categories: land size, specialization, and gender of the person in charge of the dairy farm.

It should be noted that, unless mentioned otherwise, results are based on subjective answers of farmers. This means results may be less reliable and less accurate, compared to on-farm measurements. To quantify herd performance and characteristics more reliably and accurately, on-farm measurements are needed. This will be done on a limited number of farms in the SIDPI project.

3.1 Farm categories

With regard to land size, 62% was classified as a land-based farm and 38% as a landless farm. With regard to specialization, 84% was classified as a specialized farm and 16% as a mixed crop-livestock farm. The highest percentages of mixed crop-livestock farms were found in the villages Cikole and Cibodas (43 and 41%, respectively). With regard to gender, a male farmer was in charge in 84% of the farms ('male-managed farm'), and a female farmer in 16% of the farms ('female-managed farm'). The results on gender of the person in charge of the farm were similar to the percentage of male and female registered memberships at the dairy cooperative KPSBU Jabar, with 16% female registered farms on average (varying from 5 to 33% among MCPs).

Farm categories were not significantly ($P < 0.05$) associated. Land size and specialization showed a trend toward significance ($P = 0.08$), with a higher percentage of land-based farms among mixed crop-livestock farms.

3.2 Herd composition and performance

On average, dairy herds consisted of 6.1 animals, either owned or looked after, of which 3.9 adult cows and 2.0 young stock (Table 1). Herd size ranged up to 25 adult cows (lactating and dry). Most herds (90%), however, consisted of 6 adult cows or fewer.

Average daily milk production per cow reported by farmers was 16.3 L/cow/day in the rainy season and 16.5 L/cow/day in the dry season (not significantly different between seasons, $P > 0.05$). Milk production ranged from 10 to 26 L/cow/day in the rainy season among farms, and from 10 to 30 L/cow/day in the dry season. Average lactation length was 318 days.

The daily milk production per cow estimated by farmers concerned lactating cows only. Based on KPSBU databases on the amount of milk sold by the 300 farms to KPSBU and the number of adult cows present on farms, annual milk production per adult cow was estimated at 4415 kg milk per cow/year (i.e. 12.1 L/cow/day; including dry and lactating cows). Based on KPSBU payments slips, average income from selling milk was IDR 6,344,000 per farm in the month October 2016.

With regard to reproduction², average age at first calving (AFC) was 27 months. Cows were inseminated 2.1 times until conception, with 114 open days, on average (open days are the number of days between the last calving and conception). On average cows produced 0.6 calves per year.

Main differences between farm categories:

- Land-based farms had fewer lactating cows than landless farms ($P<0.05$).
- Female-managed farms had fewer lactating cows and heifers ($P<0.01$), and a shorter average lactation length ($P<0.05$) than male-managed farms.
- No significant differences were found between mixed and specialized farms.

3.3 Land use

The majority of the farmers (84%) owned or rented land for agricultural purposes (production of grass, fodder, and food crops). Of these farmers, more farmers were renting land (59%) than owning land (41%). Part of the farmers had both owned and rented land (nearly 20%). Almost one third of the farmers rented land from the forest department. In addition, about 25% of the farmers used communal land for collecting grass.

Of those farms owning or renting land for production of grass or fodder (82% of farms), farmers used 0.31 ha of land for grass and fodder production on average (Table 1; median 0.21 ha). This implies a very high stocking density of 45.5 livestock units³ (LU)/ha (median 21.3 LU/ha). Land use and number of LU showed a weak but significantly positive correlation ($r_s=0.2$, $P<0.001$; Figure 1). Of the land used for grass and fodder production, 45% was located more than 500 meters away from the cow barn. Farmers indicated the land for grass and fodder production located furthest from their barn was 2.9 km away, on average (ranging from 200 m to 20 km).

Of those farms owning or renting land for production of food crops (16% of farms), farmers used 0.18 ha for growing food crops on average (Table 1).

Main differences between farm categories:

- As could be expected due to the categorization of land-based and landless farms (see Methods section), land-based farms had more land for grass and fodder production than landless farms ($P<0.001$).

² In the survey farmers were asked to provide information on reproduction for (maximum) 3 adult cows, randomly chosen by the farmer.

³ Cattle older than 2y are 1.0 LU, heifers 0.8 LU, and calves 0.4 LU.

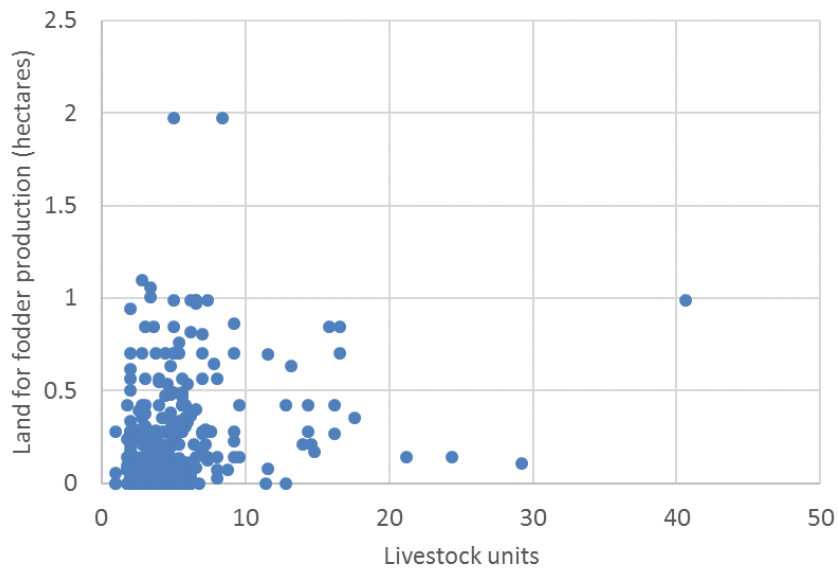


Figure 1. Land for grass and fodder production plotted against number of livestock units (LU) (cattle over 2 years old were classified as 1.0 LU, heifers as 0.8 LU, and calves as 0.4 LU; N=246 farms).

Table 1. Average¹ (standard deviation; SD) herd size, herd performance, and land use of all 300 farms in the baseline surveys, and for various categories of farms.

	Categories of farms ²						
	All farms n=300	Land-based n=186	Landless n=113	Mixed n=47	Specialized n=253	Male managed n=252	Female managed n=48
Herd size (number of animals)							
Total herd	6.1 (4.8)	5.8 (4.7)	6.5 (5.1)	5.7 (3.0)	6.2 (5.1)	6.3 (5.1)	4.9 (2.9)
Lactating cows	3.4 (2.6)	3.1 (2.2) ^a	3.8 (3.2) ^b	3.1 (1.9)	3.4 (2.7)	3.5 (2.7) ^a	2.7 (1.6) ^b
Dry cows	0.5 (1.0)	0.5 (1.0)	0.5 (0.9)	0.5 (0.8)	0.5 (1.0)	0.5 (1.0)	0.4 (0.7)
Heifers	1.0 (1.3)	1.0 (1.4)	0.9 (1.2)	1.1 (1.3)	1.0 (1.3)	1.0 (1.4) ^a	0.6 (0.8) ^b
Calves (female and male)	1.0 (1.4)	1.0 (1.5)	1.0 (1.2)	0.7 (0.9)	1.1 (1.4)	1.0 (1.4)	0.9 (1.4)
Adult bulls	0.2 (0.8)	0.2 (0.8)	0.3 (0.9)	0.3 (0.9)	0.2 (0.8)	0.2 (0.8)	0.3 (0.8)
Milk production							
Milk yield dry season (l/cow/d)	16.5 (3.3)	16.5 (3.2)	16.5 (3.4)	16.3 (2.7)	16.6 (3.4)	16.6 (3.2)	15.9 (3.5)
Milk yield rainy season (l/cow/d)	16.3 (2.7)	16.5 (2.7)	16.1 (2.6)	15.8 (2.2)	16.4 (2.7)	16.4 (2.5)	16.2 (3.5)
Lactation length (days)	317.9 (38.9)	320.0 (38.0)	314.3 (40.5)	318.9 (34.4)	317.7 (39.7)	319.8 (40.5) ^a	307.7 (27.0) ^b
Reproduction³							
Age at first calving (months)	26.7 (2.9)	26.9 (2.0)	26.4 (3.9)	25.8 (6.0)	26.9 (1.8)	26.6 (3.0)	27.6 (1.7)
Open days (days)	114.3 (46.2)	115.5 (49.2)	112.2 (40.9)	118.1 (52.8)	113.6 (52.8)	114.0 (43.9)	116.2 (58.2)
Calves per cow/year (number)	0.6 (0.4)	0.6 (0.4)	0.6 (0.4)	0.7 (0.5)	0.6 (0.4)	0.6 (0.4)	0.7 (0.4)
Inseminations per cow (number)	2.1 (1.1)	2.2 (1.2)	2.2 (0.9)	2.2 (1.0)	2.2 (1.2)	2.1 (0.9)	2.5 (1.8)
Land use							
Grass and fodder (ha) ⁴	0.31 (0.30)	0.38 (0.31) ^a	0.09 (0.08) ^b	0.32 (0.24)	0.31 (0.31)	0.32 (0.31)	0.25 (0.23)
- located >500m from cow barn	0.14 (0.19)	0.17 (0.20) ^a	0.05 (0.07) ^b	0.17 (0.17)	0.13 (0.19)	0.14 (0.19)	0.12 (0.13)
Food crops (ha) ⁵	0.18 (0.22)	0.17 (0.20)	0.20 (0.27)	0.18 (0.22)	N.A.	0.19 (0.23)	0.10 (0.11)

¹ Note all results are based on subjective farmer estimates, including average milk yield per cow/day in the dry and the rainy season.

² Averages of categories not sharing the same letter in superscript are significantly different ($P < 0.05$).

³ Information on reproduction was asked for maximum 3 cows in the herd, randomly chosen by the farmer.

⁴ Only including the farms owning or renting land for production of grass or fodder (246 farms in total).

⁵ Only including the farms owning or renting land for production of food crops (47 farms in total). Categories were not statistically compared because of small numbers of farms per category.

Table 2. Average¹ (SD) feed ration fed to lactating cows in the wet season (WS) and the dry season (DS).

	Categories of farms ²													
	All farms ³ (N=300)		Land-based (N=186)		Landless (N=113)		Mixed (N=47)		Specialized (N=253)		Male managed (N=252)		Female managed (N=48)	
	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS
Fodder (% of total fodder fed)														
Fresh cut grass (home grown)	50.9 ^a (24.1)	35.7 ^b (17.6)	56.7 ^a (21.1)	37.6 ^a (16.4)	42.0 ^b (25.9)	32.4 ^b (19.1)	54.9 (21.6)	37.3 (16.4)	50.1 (24.5)	35.4 (17.8)	50.0 (23.9)	34.9 (17.9)	55.4 (25.1)	39.9 (15.9)
Fresh cut grass (road side)	31.4 (21.5)	30.7 (20.3)	29.1 ^a (19.2)	28.5 ^a (19.1)	35.1 ^b (24.5)	34.0 ^b (21.7)	27.7 (20.5)	27.1 (20.2)	32.1 (21.7)	31.3 (20.3)	31.7 (21.6)	30.6 (20.2)	30.2 (21.4)	31.0 (21.0)
Rice straw	15.0 ^a (18.8)	31.9 ^b (20.9)	13.2 ^a (16.9)	31.5 (18.9)	18.1 ^b (21.4)	33.0 (23.9)	14.9 (19.9)	29.1 (21.2)	15.0 (18.7)	32.5 (20.9)	15.8 (19.3)	32.8 (20.9)	11.0 (15.5)	27.5 (20.7)
Other (banana stalks, vegetable waste, etc.)	0.6 ^a (3.2)	2.2 ^b (6.0)	0.5 (3.1)	2.4 (6.3)	0.6 (3.5)	1.7 (5.3)	1.1 (4.8)	4.1 ^a (8.0)	0.5 (2.9)	1.8 ^b (5.5)	0.7 ^a (3.5)	2.2 (5.9)	0.0 ^b (0.0)	2.2 (6.2)
By-products (kg fresh/cow/day)														
Tofu waste	8.8 (11.4)	8.7 (11.5)	8.0 (11.4)	7.8 (11.3)	10.3 (11.3)	10.2 (11.6)	6.9 (8.9)	6.8 (9.0)	9.2 (11.8)	9.0 (11.8)	9.3 (11.8)	9.2 ^a (11.9)	6.4 (8.3)	5.9 ^b (8.0)
Cassava waste	7.0 (6.8)	7.1 (6.9)	7.4 (6.9)	7.6 (7.0)	6.4 (6.8)	6.4 (6.7)	6.3 (4.5)	6.5 (4.6)	7.1 (7.2)	7.3 (7.3)	6.9 (6.6)	7.0 (6.7)	7.5 (7.9)	7.6 (7.9)
Brewers spent grain	0.2 (1.5)	0.2 (1.4)	0.2 (1.6)	0.2 (1.6)	0.2 (1.2)	0.2 (1.1)	0.0 ^a (0.0)	0.0 ^a (0.0)	0.2 ^b (1.6)	0.2 ^b (1.5)	0.1 (1.4)	0.1 (1.3)	0.4 (1.8)	0.4 (1.8)
Rice bran	0.1 (0.8)	0.1 (0.8)	0.2 (0.9)	0.2 (0.9)	0.1 (0.5)	0.1 (0.5)	0.0 (0.3)	0.0 (0.3)	0.1 (0.8)	0.1 (0.8)	0.1 (0.8)	0.1 (0.8)	0.0 (0.3)	0.1 (0.4)
Compound feed (kg fresh/cow/day)														
Lactating cows	6.6 ^a (3.0)	6.7 ^b (3.2)	6.9 ^a (3.1)	7.0 ^a (3.3)	6.1 ^b (2.9)	6.2 ^b (3.0)	6.3 (2.9)	6.7 (3.9)	6.7 (3.0)	6.7 (3.1)	6.7 (3.1)	6.8 (3.1)	6.0 (2.9)	6.3 (3.8)
Dry cows	2.7 (1.7)	2.7 (1.8)	2.7 (1.7)	2.7 (1.7)	2.6 (1.8)	2.6 (1.9)	2.7 (1.6)	2.7 (1.7)	2.6 (1.8)	2.6 (1.8)	2.7 (1.8)	2.7 (1.8)	2.3 (1.5)	2.3 (2.7)

¹ Note all results are based on subjective farmer estimates.

² Averages of categories not sharing the same letter in superscript are significantly different ($P<0.05$). Note only categories are compared, not seasons in categories.

³ Averages not sharing the same letter in superscript are significantly different ($P<0.05$) for the wet season and the dry season.

3.4 Feeding

3.4.1 Feed rations

In the wet season, the ration of lactating cows consisted mainly of home-grown grass⁴, followed by roadside grass and rice straw (Table 2). In the dry season, the share of home-grown grass in the ration was significantly lower than in the wet season ($P < 0.001$), and was replaced by rice straw. In the dry season the amount of rice straw in the ration was more than double the amount fed in the wet season ($P < 0.001$). Farmers fed more other fodders (mainly crop residues, such as banana stalks or vegetable waste) in the dry season compared to the wet season.

Besides fodders, farmers fed several types of industrial by-products (mainly tofu waste and cassava waste), and nearly 7 kg compound feed to lactating cows per day (fresh weight). The amount of by-products was not significantly different in the wet season and the dry season.

Farmers fed more compound feed in the dry season compared to the wet season ($P < 0.05$), though the difference was smaller than expected (100 gram per cow/day). The small difference may be due to the year in which the survey was held (2016), with substantial rainfall in the dry season. Farmers fed more compound feed to lactating cows than to dry cows.

With regards to drinking water, cows had continuous access to water in 43% of farms. In the other farms, cows were offered drinking water once (38%) or two times per day (47%). On average, lactating cows were offered 23 L/cow/day in these farms, varying from 10 to 60 litres among farms. In nearly all farms the source of water was a well or spring. In half of the farms (52%) access to drinking water for cows was limited in the dry season.

With regards to main differences between farm categories:

- In both seasons, land-based farms fed more home-grown grass, less roadside grass, and more compound feed to lactating cows than landless farms. In the wet season, landless farms fed more rice straw than land-based farms.
- Mixed farms fed more other fodders (mainly crop residues) to lactating cows than specialized farms. Specialized farms fed more brewers spent grain to lactating cows.
- Male-managed farms fed more other fodders to lactating cows in the wet season, and more tofu waste in the dry season than female-managed herds.

3.4.2 Feeding practices

The majority of farms fed fodder to cows 3 times per day (73%; Table 3), fewer farms twice a day, and almost no farms fed fodder more than 3 times per day. Specialized farms and female-managed herds fed fodder more often than mixed farms and male-managed herds, respectively.

Most farms fed compound feed to cows twice a day (70%; Table 3), and fewer farms 3 times per day. The frequency of feeding compound feed to cows did not differ across the farm types.

⁴ In the results we do not distinguish different types of grass (King grass, Mott Napier grass and Elephant grass), as only few farmers (26%) knew the difference between these types of grasses.

Most farmers (almost 90%) differentiated between dry cows and lactating cows for the amount of compound feed fed, but not between individual lactating cows in terms of milk production level or lactation stage (Table 3). Farmer also did not adjust fodder to milk production level or lactation stage. Of the farmers that did differentiate in feeding between individual lactating cows, most farmers distinguished based on level of milk production (both for fodder and compound feed).

Table 3. Percentage¹ of farms using different feeding practices (n=300 farms).

Feeding practice		% of farms
Frequency of feeding fodder (% of farms)	2 times/day	25.0
	3 times/day	72.3
	4 times/day	2.7
Frequency of feeding compound feed (% of farms)	2 times/day	70.3
	3 times/day	29.3
	4 times/day	0.3
Feeding according to individual cow requirements: fodder (% of farms)	All cows get the same amount	87.7
	Cows with higher milk production get more than others	10.7
	Cows in beginning of lactation get more than others	0.7
	Cows with higher milk production and in beginning of lactation get more than others	0.3
	Other	0.7
Feeding according to individual cow requirements: compound feed (% of farms)	Lactating and dry cows get the same amount of compound feed	11.3
	All lactating cows get the same amount of compound feed	90.3
Compound feed is mixed with water	Yes	84.3
	No	15.7

¹ Note results are based on subjective farmer estimates.

3.4.3 Feed costs

Less than half of the farmers bought fodder (46%). Of the farmers buying fodder, most bought rice straw (97%), and fewer bought grass (11%). Other fodders bought were banana stalks, vegetable waste and green maize.

With regard to expenditures on feed and fodder, farmers indicated they spend most on purchasing compound feed (IDR 1,615,000/month, on average) and by-products (IDR 1,496,000/month), and much less on fodder and supplements (IDR 245,000 and IDR 31,000/month). Only two farmers sold fodder.

3.4.4 Perceptions of farmers

Most farmers were satisfied with the availability and the quality of green fodder, by-products, compound feed, and supplements (Table 4 and 5). Some farmers were dissatisfied with the quality of compound feed and supplements. There were hardly any differences in average satisfaction between farm categories.

Table 4. Perception of the availability of fodders and feeds (N=300 farms).

Satisfaction with availability of: (% of farms)	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied
- green fodder	1.0	75.3	21.0	2.7	0
- by-products	0	85.0	14.3	0.7	0
- compound feed	0.7	89.3	8.0	2.0	0
- supplements	0	73.7	26.0	0.3	0

Table 5. Perception of the quality of fodders and feeds (N=300 farms).

Perception of the quality of: (% of farms)	Very good	Good	Average	Poor	Very poor
- green fodder	0.7	78.0	19.7	1.7	0
- by-products	0.7	72.7	26.3	0.3	0
- compound feed	0.3	53.7	37.0	9.0	0
- supplements	0.3	63.7	29.0	7.0	0

Even though the majority of farmers was satisfied with the availability of green fodder, most farmers indicated they have problems accessing sufficient green fodder during the dry season (87%; Figure 2). A few farmers indicated having problems during the wet season or throughout the whole year. Mixed farms less often had problems accessing sufficient green fodder during the dry season than specialized dairy farms (96% vs. 86%).

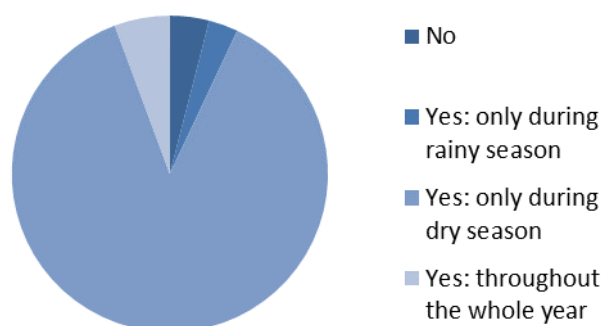


Figure 2. Problems with access to sufficient green fodder (% of farms).

3.5 Manure

Different terms are used for the various types and forms of cattle excreta. In this report we use the following definitions:

- **Urine:** the pale yellow fluid stored in the urinary bladder and excreted by urination. Urine typically contains less than 4% dry matter and the larger part of total excreted nitrogen and potassium salts.
- **Feces** (or '**dung**'): the solid or semisolid remains of the food that could not be digested in the small intestine and discharged through the anus by defecation. Feces typically contain 12 -15% dry matter, and the larger part of total excreted phosphorus and organic matter.
- **Manure:** general term for feces, either with (e.g. slurry) or without urine (e.g. cow pies). The dry matter content may vary.
- **Slurry:** liquid mixture of feces and urine. Slurry typically contains 5-10% dry matter.
- **Solid manure:** stackable manure, obtained by solid-liquid separation of feces and urine, and/or drying of the separated solids. Solid manure typically contains more than 20% dry matter.
- **Digestate** (or '**bio-slurry**'): the liquid by-product from biogas production (or 'anaerobic digestion'). Digestate typically contains less than 10% dry matter. All the nutrients in the input slurry (N, P, K, etc.) remain in the digestate. The biogas contains digested carbohydrates (mainly gaseous methane CH₄ and carbon dioxide CO₂). Biogas can be highly toxic to humans and animals because of the presence of small quantities of gaseous hydrogen sulphide (H₂S), depending on the sulphur levels in feed ingredients.
- **Compost:** a concentrated, stabilized soil improver made from solid manure and additives, typically containing more than 60% dry matter in the finished compost. Compost is obtained through a bio-thermal aerobic treatment⁵ of manure and additives, which is an autonomous temperature increase due to bacterial activity, accompanied by a reduction in moisture due to release of water vapour and a reduction in the numbers of pathogens. Nitrogen loss during composting varies between 20 and 60%.
- **Aerobic:** with air supply (hence, with oxygen).
- **Anaerobic:** without air supply (hence, without oxygen).

3.5.1 Final destinations of manure

Figure 3 shows the *percentage of farms* with different final destinations of manure. Manure (either feces, urine, or both) was discharged to the environment in 84% of the farms, used for fertilization of owned fodder in 32% of the farms, used for fertilization of owned crops in 10% of the farms, and sold or given away in less than 10% of the farms (Figure 3; total exceeds 100% because multiple answers were allowed). In nearly 20% of the farms, there was another destination of manure. The final destination of manure did not differ much between the wet and the dry season.

⁵ In the composting process, regular turning of the heap and adding inoculation material (finished compost from another batch) will improve aeration and speed up the process. Additives like rice husks and straw can be used to increase porosity of the material (for better aeration) and to increase the dry matter content of compost. Adding water to the heap may be necessary if the dry matter content gets below 40%. The composting process may last from several weeks up to several months, depending on the characteristics of the input materials and the degree of process control.

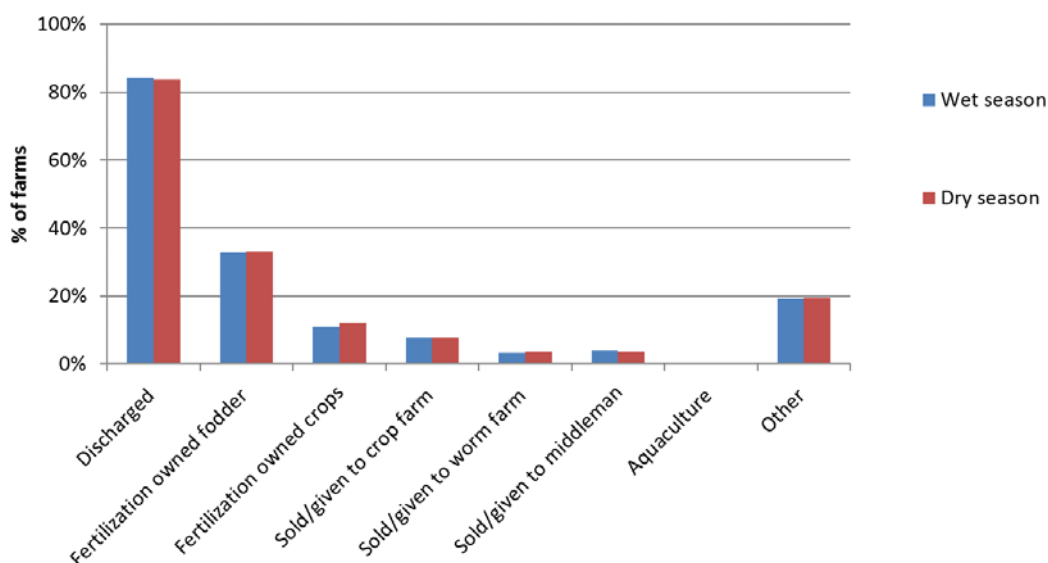


Figure 3. Percentage of farms with different destinations of manure (total exceeds 100% because multiple answers were allowed).

In many farms, however, not all the manure was used for the final destinations described above and in Figure 3. For example, the percentage of farms discharging *all* manure was 45%, whereas 39% of the farms discharged only part of the manure (either dung, urine, or both). Similarly, the percentage of farms using *all* manure for fertilization of owned fodder was 5%. Table 6 shows the *share* of total manure produced on the farm with different destinations. On average, 61-62% of the manure was discharged to the environment, 21% was used for fertilization of own land for production of fodder or food crops, less than 10% of the manure was sold or given away, and less than 10% went to an 'other' destination.

Few farmers (7%) incidentally sold or gave away large amounts of cattle manure. Percentage of farms selling or giving away manure was largest among landless farms (11%, compared to 4% in land-based farms). On average, farmers selling manure earned IDR 3,364,000 per year from manure sales. Most farmers (71%) indicated manure management on their farm was similar to that of others in their farmer group. Only few farmers (5%) indicated manure or manure sales was managed together as a group.

Differences between farm categories (Table 6):

- In both seasons, land-based farms used a larger share of the cattle manure for fertilization of owned land for fodder production than landless farms;
- In both seasons, specialized farms discharged a larger share of the cattle manure, and sold a larger share to middlemen than mixed farms. Mixed farms used a larger share for fertilization of owned land for food crop production;
- No significant difference was found between male- and female-managed farms, except that male-managed farms allocated more manure to the destination 'other' in the dry season than female-managed farms.

Table 6. Average¹ share (SD) of cattle manure with different final destinations.

Destination	Categories of farms													
	All farms (N=300)		Land-based (N=186)		Landless (N=113)		Mixed (N=47)		Specialized (N=253)		Male managed (N=252)		Female managed (N=48)	
	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS
Discharged to the environment	62.0 (40.0)	61.3 (40.0)	60.9 (39.5)	60.0 (39.4)	64.2 (40.9)	63.5 (41.1)	50.0 ^a (36.1)	50.4 ^a (34.8)	64.2 ^b (40.3)	63.3 ^b (40.6)	61.1 (40.0)	61.0 (39.8)	66.9 (39.7)	62.7 (41.2)
Fertilization of own land: fodder	16.9 (29.2)	16.7 (28.6)	20.7 ^a (32.0)	21.0 ^a (31.7)	10.5 ^b (22.8)	9.3 ^b (20.9)	16.7 (23.5)	16.3 (20.2)	17.0 (30.2)	16.7 (30.0)	17.4 (29.9)	16.5 (28.7)	14.4 (25.6)	17.4 (28.3)
Fertilization of own land: crops/vegetables	4.1 (13.7)	4.0 (12.8)	3.6 (12.1)	4.0 (12.0)	4.6 (15.9)	3.8 (13.8)	16.2 ^a (21.5)	14.5 ^a (20.0)	1.8 ^b (10.3)	2.0 ^b (9.8)	3.9 (13.3)	3.8 (12.5)	5.2 (15.9)	4.7 (14.2)
Sold/given to crop/vegetable farms	3.7 (15.6)	3.8 (16.0)	3.1 (14.5)	2.9 (14.4)	4.7 (17.3)	5.4 (18.3)	6.1 (20.0)	6.7 (20.9)	3.2 (14.6)	3.3 (14.8)	3.3 (14.3)	3.5 (14.7)	5.6 (21.3)	5.6 (21.3)
Sold/given to worm farms	1.3 (8.7)	1.6 (10.5)	1.9 (10.6)	1.8 (10.5)	0.4 (3.8)	1.3 (10.5)	3.7 (16.5)	3.6 (16.3)	0.9 (6.3)	1.3 (9.0)	1.4 (9.3)	1.8 (11.4)	1.2 (4.8)	0.8 (3.5)
Sold/given to middlemen	3.1 (16.3)	2.8 (15.4)	2.2 (12.9)	2.3 (13.1)	4.6 (20.8)	3.8 (18.7)	0.0 ^a (0.0)	0.0 ^a (0.0)	3.7 ^b (17.7)	3.3 ^b (16.7)	3.3 (16.7)	2.9 (15.6)	2.1 (14.4)	2.1 (14.4)
Aquaculture (own or other farm)	0.2 (2.9)	0.0 (0.0)	0.3 (3.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.2 (3.1)	0.0 (0.0)	0.2 (3.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Other	8.9 (21.8)	9.3 (22.1)	7.5 (19.6)	8.1 (20.1)	11.2 (24.9)	11.3 (25.2)	7.6 (19.0)	8.7 (20.0)	9.1 (22.3)	9.4 (22.6)	9.7 (22.9)	10.3 ^a (23.5)	4.8 (13.8)	4.0 ^b (12.3)

¹ Note results are based on subjective farmer estimates.

3.5.2 Manure management practices

Collection

Manure was collected actively in 40% of the farms, either by collecting the faeces only (27%) or both faeces and urine ('slurry'; 13%). Of those collecting faeces only, most of the farmers collected half (30% of farms), more than half (17%), or nearly all (32%) of the faeces. Of those collecting slurry, most of the farmers collected half of the slurry (56% of farms), more than half (13%), or nearly all (18%).

Both when faeces were collected separately and when slurry was collected, anaerobic digestion was the most common destination (33 and 54% of farms). Second most important destination of collected faeces was fertilization of own fodder (26%). Both faeces and slurry were sold or given away to crop/vegetable farms (6 and 10% of farms), but only separately collected faeces were sold/given to worm farms (6% of farms).

In nearly all farms (99%), manure (dung, urine, or both) was flushed away with water from barns and floors. On average manure was flushed 2.6 times a day, and slightly more often in the wet season than in the dry season. Average frequency of flushing was lowest in mixed farms (2.4 times a day in WS).

Storage and treatment

Of the farmers collecting manure on their farm, 66% stored the manure during the whole year, 20% did not store the manure, and 14% stored manure only part of the year (during dry season only, rainy season only, or incidentally when demand from crop/vegetable farmer is high). Most common types of manure storage used were a manure heap (60% of farms), or 'other' (38%).

Of the farmers collecting manure on their farm, 30% actively dried manure, 20% actively composted manure, and 14% performed vermi-composting (adding worms to the compost).

Anaerobic digestion of manure was used on 35% of the farms, with an average holding capacity of 6.5 m³. Only faeces, urine, and flushwater were entered in the digester (hence, no feed leftovers, crop residues, garbage, or other materials). In most of these farms (83%), half or less than half of the manure was used for anaerobic digestion. After leaving the digester, the digestate was discharged (31% of the farms with a biodigester), used as a fertilizer for fodder production on own land (38%), used as a fertilizer for crops/vegetables on own land (7%), sold/given to a crop/vegetable farm (12%), sold/given to a worm farm (3%), or other (8%).

Differences between farm categories:

- There were no differences in storage and treatment between farm categories, except for land-based farms actively composting more often than landless farms (0.3 vs. 0.1% of farms; $P < 0.05$).

Transport

For fertilization of land used for fodder production close to the cow barn, most farmers transported manure on foot or in an 'other' way. With 'other', farmers most likely meant letting liquid manure flow to fields via gravity (e.g. via pipes). For fertilization of land for fodder production located further away from the cow barn, the most common vehicle for transporting manure was a motorbike (40% of farms), on foot (27%), car or truck (20%), or other (13%). For fertilization of food crops/vegetables, the most common vehicle for transporting manure was a motorbike (50% of farms), or on foot (41%).

3.5.3 Fertilization practices

Fodder production

Fertilization practices on land used for fodder production (N=246 farmers) differed among owned, rented and communal land, and for the distance from the barn to the land:

- On owned land, nearly all farmers applied fertilizer (synthetic fertilizer or animal manure⁶), regardless of the distance to the land (Figure 4). The type of fertilizer used varied according to distance to land, however, with manure being the most common type applied to land close-by, and synthetic fertilizer the most common type applied to land further away from the barn (Figure 5);
- On rented land, more than half of the farmers applied fertilizer on land close-by, and less than half applied fertilizer on land further away. Likewise owned land, the most common type of fertilizer applied to land close-by was cattle manure, while synthetic fertilizer was more often applied to land located further away;
- On communal land, less than 20% of farmers applied fertilizer (both synthetic fertilizer and cattle manure).

Nearly half of the farmers indicated to purchase synthetic fertilizer, which was mostly urea (few used NPK).

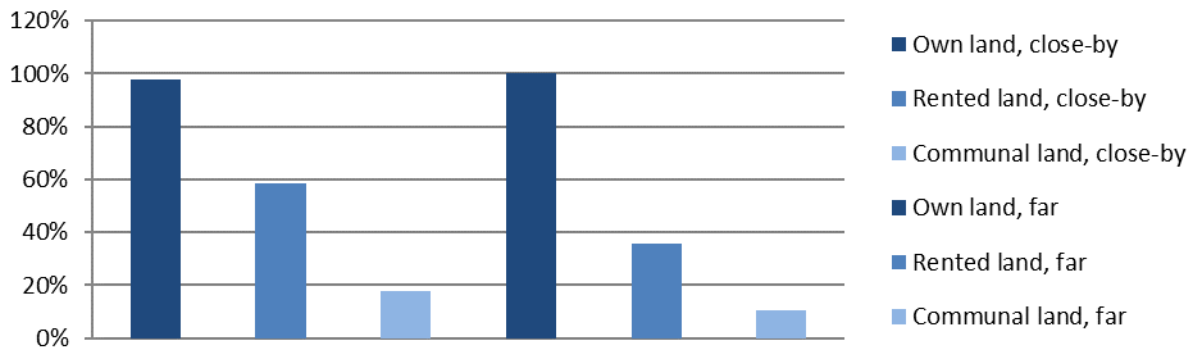


Figure 4. Percentage of farmers with land for fodder production (N=246) who fertilized their land. Results are shown separately for owned, rented and communal land, and for land located close-by (<500m) or further away from the cow barn (>500m from barn).

⁶ Answering options were: (a) synthetic fertilizer, (b) cattle manure, (c) chicken manure, (d) other organic fertilizer. Option d was not selected by any farmer.

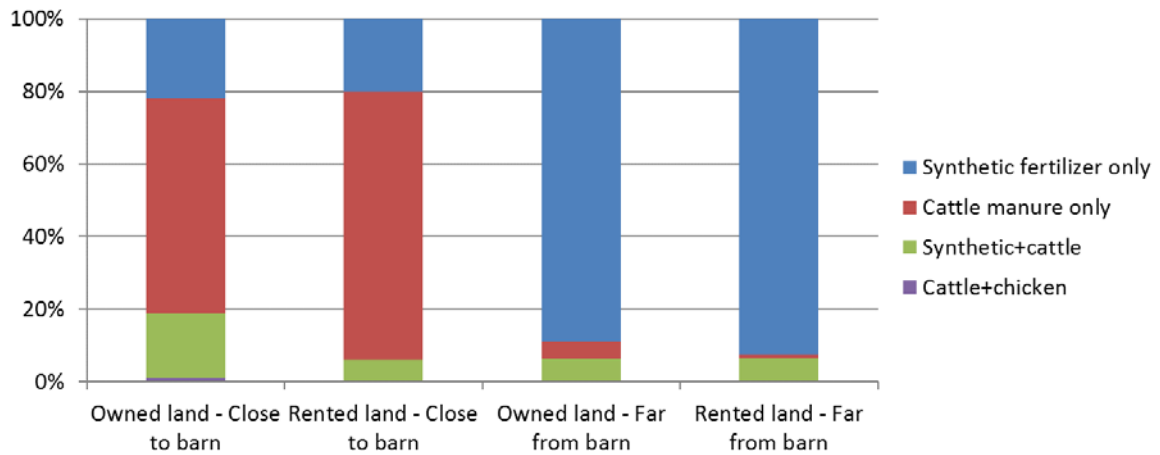


Figure 5. Type of fertilizer applied on land for fodder production (% of farms).

It can be concluded that almost 80% of the farmers *owning* land close to the barn applied cattle manure on this land (Figure 4 and 5). Of those farmers *renting* land close to the barn, almost half of the farmers applied cattle manure on this land. These results correspond to the results described in paragraph 3.5.1 (final destinations of manure), which showed that 45% of all farms in the baseline survey did not use any cattle manure as fertilizer on land, because all was discharged.

Food production

For food crop production on dairy farms (mixed crop-livestock farms; N=47 farmers), farmers used different types of fertilizer (Figure 6). Farmers used relatively more cattle manure when the land was located closer to the cow barn, and more synthetic fertilizer when located further away from the cow barn.

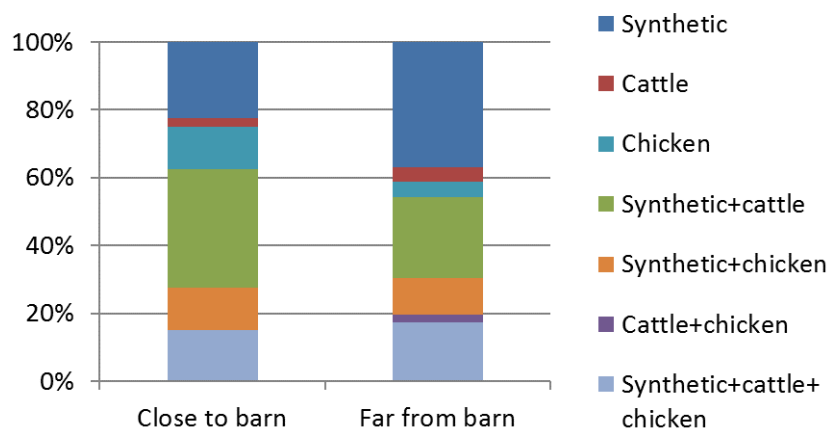


Figure 6. Type of fertilizer applied on crops in mixed dairy-crop farms (n=48).

3.5.4 Perceptions of farmers

The majority of farmers considered manure as a valuable product (77%) and not a waste product. Most important reasons for considering manure as a valuable product were the increase in crop yields when applied to land, manure being an ingredient for biogas production, and maintaining soil fertility of land (Figure 7). Fewer farmers indicated its value for feeding of fish or worms, and for income from selling manure.

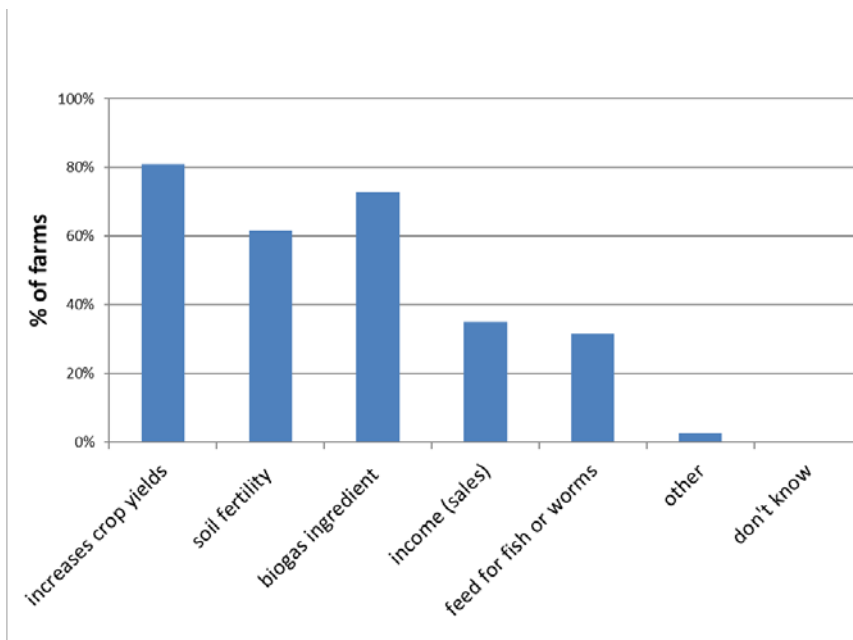


Figure 7. Reasons why farmers consider manure as a valuable product (N=232).

Although most farmers discharged manure (84%, see paragraph 3.5.1), 83% of the farmers acknowledge discharging manure into the environment is a problem. Reasons indicated by farmers why discharging manure is a problem were nuisance (80% of farms), pollution of water streams and rivers (76%), and disease risk for cattle and humans (69%; multiple choice question).

Most important reasons for discharging were insufficient room to store the manure, labour requirements of manure management, land being located far away or hard to reach, and difficulty of handling and transporting manure (Figure 8).

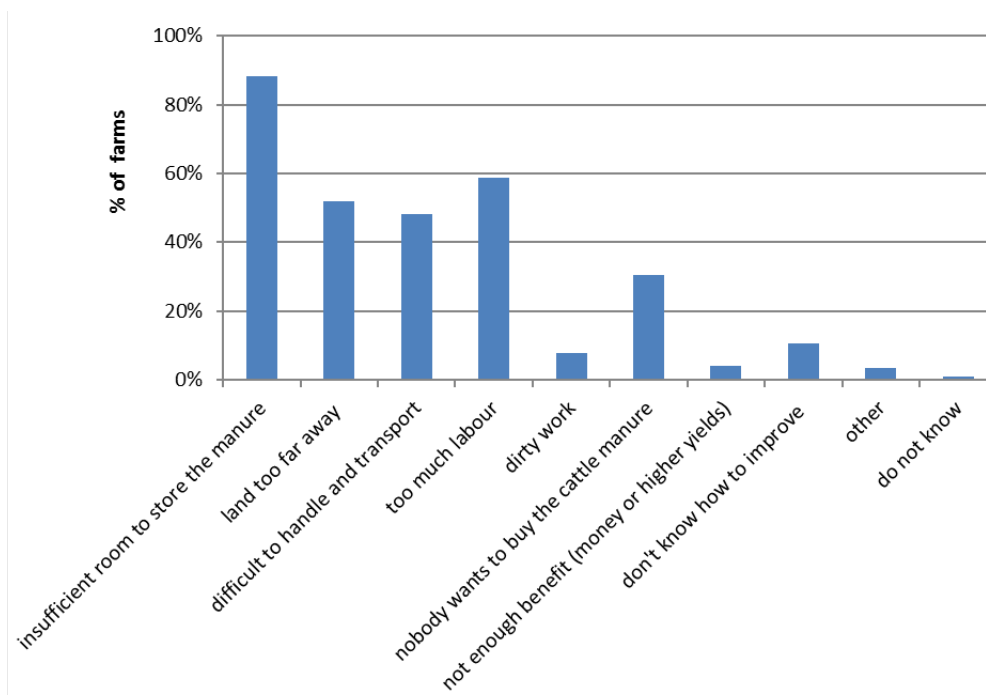


Figure 8. Reasons for discharging (part of the) manure into the environment.

Most farmers were satisfied with their current manure management practices (Figure 9).

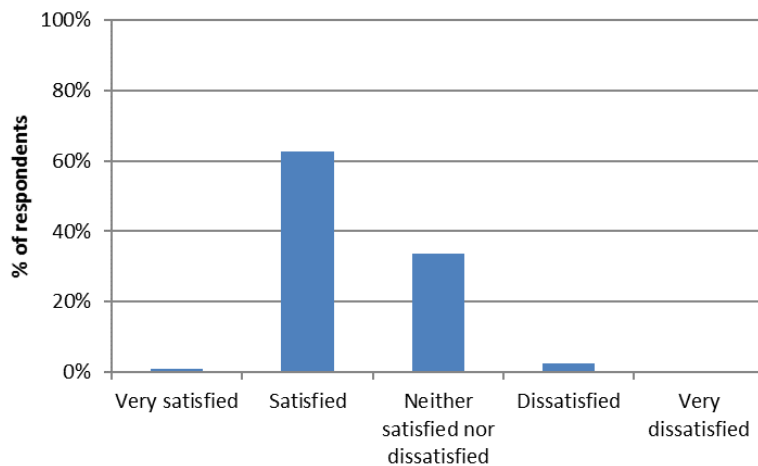


Figure 9. Satisfaction with current manure management practices (% of farms).

Differences between farm categories:

- Female farm managers less often perceive manure as a valuable product than male managers (63 vs 80%; $P < 0.01$). Female managers more often indicate they are not selling or utilizing manure because it takes too much labour, and they do not know how to improve manure management than male managers (73 vs 57% and 24 vs 8%; $P < 0.05$);
- Specialized farmers less often perceive manure as a valuable product than mixed farmers (75 vs 92%; $P < 0.01$);
- Landless farmers less often perceive manure as a valuable product than land-based farmers (68 vs 83%; $P < 0.01$). Landless farmers more often indicate they are not selling or utilizing manure because nobody wants to buy the manure and it does not give enough benefit (money) than land-based farmers (48 vs 21% and 9 vs 2%; $P < 0.001$ and $P < 0.05$).

3.6 Labour

Cutting and collecting grass were the most time consuming activities on the dairy farm (3.15 hours; Table 7), followed by milking (1.09), cleaning the cows (1.04), feeding cows (0.80) and cleaning the barn (0.77). Cows were washed in 93% of the farms, of which 83% washed cows once a day, and 2% twice a day. Nearly all farmers washed the whole cow (97%), whereas only few washed the udder or teats only (3%).

In most farms 2 or 3 people were working on the farm (55% of farms) or one (35%). In few farms, 3 or 4 people were working on the farm. Most farms are run by the household: in a few farms non-household members worked on the farm. Activities were mainly executed by the respondent him/herself, followed by their spouses. The respondent spent on average 6 hours 42 minutes per day on dairy farm activities, and the spouse 1 hour 37 minutes. Other persons working on the farm were sons and other male household members. Daughters and other female household members hardly worked on the farm.

Table 7. Activities at the dairy farm: main household member responsible (mean hours/day).

	Total	Respon- dent	Spouse	Son	Other male	Daugh- ter	Other female
<u>Feeding</u>							
Feeding cows	0.80	0.55	0.17	0.03	0.05	0.00	0.00
Providing drinking water to cows	0.35	0.25	0.06	0.02	0.02	0.00	0.00
Feeding calves	0.20	0.13	0.05	0.01	0.01	0.00	0.00
Cutting/collecting grass	3.15	2.32	0.48	0.21	0.13	0.01	0.00
Preparing concentrate feed	0.55	0.38	0.11	0.03	0.03	0.00	0.00
Making silage	0.01	0.01	0.00	0.00	0.00	0.00	0.00
<u>Milking</u>							
Milking the cows	1.09	0.84	0.12	0.07	0.05	0.01	0.00
Transporting milk to MCP	0.41	0.31	0.04	0.03	0.02	0.00	0.00
<u>Cleaning</u>							
Cleaning cows	1.04	0.74	0.19	0.08	0.03	0.01	0.00
Cleaning barn	0.77	0.52	0.17	0.05	0.03	0.00	0.00
<u>Manure management</u>							
Collection	0.44	0.31	0.09	0.02	0.01	0.00	0.00
Transport	0.18	0.12	0.03	0.01	0.01	0.00	0.00
Application	0.16	0.11	0.04	0.01	0.00	0.00	0.00
<u>Other</u>							
Purchasing inputs	0.10	0.07	0.02	0.00	0.00	0.00	0.00
Book keeping of dairy business	0.08	0.04	0.04	0.00	0.00	0.00	0.00
Total activities	9.31	6.70	1.61	0.57	0.40	0.04	0.00

3.7 Farmer interest in learning

Farmers showed interest in learning about:

- animal health management (62%);
- application of manure on the farm (60%; especially female-managed (67%) and mixed farms (72%));
- selling manure to middleman (52%);
- improving feeding practices (50%);
- selling manure to crop/vegetable farmers (47%);
- human health risks related to drinking milk (41%);

Unsolicited but mentioned as other topic by 10% of the farmers, was the topic of how to increase milk production. Most farmers preferred to receive a training (95%), followed by farmer field trips (70%), and social media messages (7%).

4 Discussion

This study showed that dairy farms in Lembang district are mostly small-scale zero grazing dairy farms, with most farms (90%) consisting of 6 dairy cows or fewer. Average milk production per cow varied substantially among herds, from 10 to 26 L/cow/day, which indicates there is room for improving milk production in Lembang dairy herds. The same accounts for reproductive performance. Results of farming characteristics showed which aspects may be hampering milk production of dairy farms in Lembang. Based on this, barriers and opportunities for improvement can be identified. It should be noted that results from the baseline survey were based on answers from farmers, which may reduce the reliability and accurateness of results. To more accurately assess herd performance and farming practices, on-farm measurements are required. In addition, results presented in this report were limited to descriptive statistics. A more in-depth analyses of associations could provide more insight in factors influencing herd performance and resource use efficiency.

Land use

The small area of land and high stocking densities per farm (on average 45 LU/ha) explained why obtaining sufficient green fodder is challenging for dairy farmers. The lack of green fodder limits the possibilities to increase milk production, especially in landless dairy farms. The scarcity of land and the competition for space among sectors on Java is expected to further increase in the future (Verhaeghe and Zondag, 2009). In order to tackle these problems, the dairy sector on Java needs to develop a spatial development strategy, with land-based dairy farming being key to sustainable development. In addition, optimizing grass yields can help to improve land use efficiency and make optimal use of scarce land resources.

In a similar vein, a large part of the land was located far away from cow barns. This disconnection of land and milk production explains why collection of fodder was the most labour intensive activity on dairy farms, leads to high transport costs, and makes recycling of manure as a fertilizer extremely difficult (del Corral et al., 2011). A spatial development strategy for the dairy sector on Java should thus include a land consolidation policy (i.e. readjustment of land parcels) to reduce the high degree of land fragmentation in dairy farming on the longer term.

Feeding

Farmers fed more rice straw in the dry season because less green fodder is available in the dry season. This was also found in other studies (e.g. Fella et al., 2009). Since straw is of low nutritional quality, farmers increase the amount of concentrate feed in the dairy ration to maintain milk production levels. This feeding strategy has several negative side-effects. First, rice straw has a low palatability causing a lower forage intake by ruminants. Secondly, feed costs per kg of milk increase due to the relatively high price of concentrate feeds. Third, feeding concentrates in excess carries animal health risks, such as displaced abomasum, acidosis, and poorer reproductive performance. Fourth, the high carbon footprint of compound feed and rice straw cause higher GHG emissions during the dry season. Alternatives to rice straw should be explored, such as feeding a better quality conserved feed in the dry season (e.g. maize or grass silage), or improving the nutritional quality of rice straw. With regard to the latter, fungal treatment may be a promising technique to improve the digestibility of straw (e.g. Tuyen et al., 2013).

With regards to feeding practices, the majority of farmers did not adjust the feed ration of lactating cows to milk production level or lactation stage (fodder nor compound feed). Balancing feed rations of cows according to nutritional requirements can contribute to increased milk yields, and minimize feed costs. Balanced rations have also been shown to reduce GHG emission intensity (Garg et al., 2013). In more than half of the farms cows did not have continuous access to water, which can reduce milk yields of cows.

Manure

Results showed that most farms discharged at least part of the manure into the environment. Discharging of manure may cause local nuisance, pollution of ground and surface water (problems with drinking water quality), and contributes to increased GHG emissions. Moreover, manure is a valuable source of nutrients, which are lost when discharged. Replacing lost nutrients by synthetic fertilizer is expensive and leads to additional GHG emissions. Hence, discharging of manure causes both environmental and social problems. Efforts should be made to utilize manure as a fertilizer on land for fodder and food production.

A third of the farms used manure for fertilization of land for fodder production, and fewer farms used it for fertilization of food crops, or sold manure. Nearly all farmers owning land close to the cow barn applied cattle manure on this land. This was most likely due to the fact that with gravity, liquid slurry can easily flow directly and continuously to the field, e.g. via pvc pipes. Given the liquid character of bio-slurry, the combination of digestion and application of bio-slurry on land close-by is ideal. This implies there is less need to enhance application of cattle manure on land located close to barns (except for those renting land, who apply less). Methods of application, however, may need to be improved, such as an appropriate distribution across the field, to optimize grass yields and to avoid over-fertilization leading to nutrient leaching.

On land located further away from the cow barn only very few farmers applied cattle manure. Most farmers applied synthetic fertilizer on these fields, which is relatively light weight and contains a much higher concentration of nutrients than animal manure. On the other hand, using cattle manure for fertilization could reduce costs of synthetic fertilizer. To enhance the use of cattle manure as a fertilizer on land located further away from the barn, production of solid manure should be stimulated, which is easier to handle and transport. Examples are farm yard manure, compost, or the solid fraction of mechanically separated manure.

Production of solid manure requires locally suitable methods for manure collection, storage, and transport. With regard to collection, the regular flushing of barns and washing of cows with water is a hindrance to production of solid manure. To produce solid manure with a high nutrient content and low moisture for efficient handling and transport, dry collection of faeces is needed. With regard to storage, results showed 20% of the farms in the survey stored manure on a manure heap, and about 8% produced compost. These farms could serve as examples. With regard to transport, most farmers transport manure on the motorbike, on foot, or with a car or truck. Time-wise, most economical is to bring manure to the field when going out for collecting fodder. Urine should be used as fertilizer on fields located close to the cow barn.

Farmer perceptions

The survey showed that farmers do acknowledge certain problems in dairy farming, such as the problem of accessing sufficient green fodder in the dry season, and discharging manure being a

problem. At the same time, only few farmers indicated they were dissatisfied with the availability and quality of fodders and feeds, and almost none of the farmers was dissatisfied with the current manure management on his/her farm.

Nevertheless, more than half of the farmers showed interest in learning about manure management and improving feeding practices. In addition, they expressed interest in increasing milk production. This suggests farmers are motivated to improved feeding and manure management on their farms, which can contribute to improving milk production and income from their farm, and reduce environmental impacts.

Sustainable intensification

This study showed that current feeding and manure management practices in Lembang are hampering productivity of dairy farms, and also lead to inefficient use of resources, such as nutrients (nitrogen, phosphate, potassium) and land (feed and food). The challenges of obtaining sufficient and good quality feed and recycling of livestock waste are common in many regions with a high livestock density in Southeast Asia. Improvements for feeding and manure management suggested in this study are examples of 'sustainable intensification', which means more is produced from the same resources while negative impacts on the environment are reduced (adapted from FAO, 2011). Resource use efficiency is very important for small-scale farmers in developing countries, who are often coping with resource scarcity. In Indonesian dairy farms, efficiency gains can be mainly achieved through improved feeding, improved nutrient recycling (manure management and fertilization), and animal health. To improve feed and nutrient use efficiency, regional and on-farm integration of feed production and manure utilization are key (Martin et al., 2017).

5 Conclusions

The increasing demand for dairy products in Indonesia may offer possibilities for Indonesian dairy farmers to increase milk production, and improve their incomes and livelihoods. This study showed dairy farms in Lembang district are mostly small-scale, zero-grazing dairy farms with high stocking densities per unit of land, and a milk production level and reproductive performance below potential. The scarcity and fragmentation of land are causing challenges of obtaining sufficient and good quality fodder, and recycling of manure as a fertilizer. In addition, poor feeding and to improper waste management on farms can lead to high feed costs, sub-optimal milk production and fertility of cattle, as well as environmental and social problems. Results indicate there is room for improvement of feeding and manure management practices, which may not only contribute to improved farm productivity, but also to improved resource use efficiency and reduction of environmental impacts of dairy farming. Sufficient land base is a key condition to sustainable development of dairy farming in Lembang district.

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7 References

- del Corral, J., J. A. Perez, and D. Roibas. 2011. The impact of land fragmentation on milk production. *Journal of Dairy Science* 94: 517-525.
- FAO. 2011. Save and grow. A policymaker's guide to the sustainable intensification of smallholder crop production. Food and Agriculture Organization of the United Nations, Rome.
- Fella, A., I. G. Permana, and Despal. 2009. Differences nutrition quality of forage during wet and dry seasons and their impact on milk production and quality in Barunagri village, Lembang Regency. Thesis. Bogor Agricultural University. <http://repository.ipb.ac.id/handle/123456789/59787> Bogor, Indonesia.
- Garg, M. R., P. L. Sherasia, B. M. Bhanderi, B. T. Phondba, S. K. Shelke, and H. P. S. Makkar. 2013. Effects of feeding nutritionally balanced rations on animal productivity, feed conversion efficiency, feed nitrogen use efficiency, rumen microbial protein supply, parasitic load, immunity and enteric methane emissions of milking animals under field conditions. *Animal Feed Science and Technology* 179: 24–35.
- Martin, N. P., M. P. Russelle, J. M. Powell, C. J. Sniffen, S. I. Smith, J. M. Tricarico, and R. J. Grant. 2017. Invited review: Sustainable forage and grain crop production for the US dairy industry. *Journal of Dairy Science* 100: 9479-9494.
- Seré, C. and H. Steinfeld. 1995. World Livestock Production Systems. Current Status, Issues and Trends. FAO Animal Production And Health Paper No. 127. Food and Agriculture Organization of the United Nations, Rome.
- Tuyen, D. V., H. N. Phuong, J. W. Cone, J. J. P. Baars, A. S. M. Sonnenberg, and W. H. Hendriks. 2013. Effect of fungal treatments of fibrous agricultural by-products on chemical composition and in vitro rumen fermentation and methane production. *Bioresource Technology* 129: 256 - 263.
- Verhaeghe, R. J. and B. Zondag. 2009. Challenges in spatial planning for Java. in 9th Indonesian Regional Science Association (IRSA) International Conference. The Current and Future Issues of Regional Development, Energy and Climate Change. Indonesia.



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