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https://doi.org/10.5109/4552

出版情報：九州大学大学院農学研究院紀要. 48 (1/2), pp.307-323, 2003-10-01. Faculty of Agriculture, Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., **48** (1·2), 307–323 (2003)

A Study on The Optimal Plans of Dairy Farming in Hanoi and Hochiminh City by Linear Programming Method

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(Received April 30, 2003 and accepted July 15, 2003)

There are many feasible farm plans which can be actually applied by farmers. However, to find the optimal plan which maximizes farming income of household, a specific calculation is needed. In this study, we use proper data compiled from interviewing 46 dairy households in Phudong commune in Hanoi and 40 dairy households in Tanxuan commune in Hochiminh City to find the optimal dairy farm plan based on the linear programming method.

Through analyzing the actual working conditions and estimating the coefficients of related linear programming problems, we tried to attain the expected objectives of the study: 1) Better understanding about dairy farming system in the study areas, 2) Finding the optimal plans of dairy production in Hanoi and Hochiminh city, 3) Analyzing factors affecting optimal plans and 4) Giving farmers some possible advises.

The result of the study shows the ineffectiveness of the present plans of both dairy farmers in Hanoi and Hochiminh City. It also reveals the reasons for those inefficiencies and the importance of appropriate use and allocation of available family resources. Finally, the study tends to give useful advises to dairy farmers about how to reallocate their resources depending on their capital investment to maximize their income.

INTRODUCTION

Unlike the traditional rice enterprise, which has been done a thousand years in Vietnam, dairy production has just been new for most Vietnamese farmers; even it has not been introduced to all possible cow–raising regions. It is often found that non–dairy farmers use land resource for monoculture of rice production and dairy farmers still prefer to till some rice rather than grow grass to enlarge their dairy farm size. Reasons, on the one hand, of their preference are the less risk, the more simple technique and smaller capital requirement of rice cultivation, even though it is less profitable in comparison with dairy production. On the other hand, at present, family labor force can manage to collect enough fodder for their few numbers of cows. Demand on green fodder in Hanoi and Hochiminh city has not reached the level of high incentives that encourages farmers to supply grass for a green fodder market. However, on the long run, when capital is no longer an obstacle of expanding dairy farm size, farmers will have to balance labor on activities such as how much area they should use for rice enterprise, how much area they should grow grass and how many cows they should keep, given other factors fixed. A

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study on finding optimal plans of dairy production is needed not only in Hanoi and Hochiminh city but also in other dairy production regions to give farmers useful advises to improve their farm income.

Objectives of study

The general objective of this study is to guide farmers in Hanoi and Hochiminh city in planning their farm plans relating to a mixed farming system of crops and dairy production by using family labor force at current situation of working conditions in order to maximize income from farming. The specific objectives are given bellow:

1. Better understanding about dairy farming system in the study areas,
2. Finding the optimal plans of dairy production in Hanoi and Hochiminh city,
3. Analyzing factors affecting optimal plans,
4. Giving farmers some possible advises.

Methodology

Results of the study will be given by using the linear programming model. Proper data selected from interviewing 46 dairy households in Phudong commune–Gia Lam district of Hanoi and 40 dairy households in Tanxuan commune–Hocmon district of Hochiminh city will be used to estimate coefficients and restrictions for the basic situation. Then optimal plans will be traced by changing some available resources such as shed and capital, and modifying coefficients of variables through alternative prices of them such as price of milk and price of green fodder.

The model used

Due to the mixed characteristic of farming system in Vietnam, output of one activity might be input of the other. For every dairy farmer, labor, land and cows are what they have. Most of farmers rear dairy cows and cultivate different rotation of crops such as rice, maize and grass. Manure from cows will be partly used to fertilize the crops and harvested crops will be partly used to feed cows. The problem is to suggest farmers how many cows they should rear, what crops they should plant to maximize their income from utilizing their available resources. How does the optimal plan change if the available resources and prices of related resources alter? Is linear programming suitable to this purpose?

Mathematically Linear Programming Problem is specified as follows: Maximize a linear objective function of non–negative real variables subject to linear inequalities of the variables.

The linear programming is a model that can be used to select a combination of the levels of various activities which will maximize the income–to determine an optimum program or one which maximizes the objective function. But any option selected must be a feasible one. A feasible option is one which does not have total resource requirements exceeding the total resource supplies. There usually are an infinite number of feasible options for even a small programming problem, but generally there is only one optimal feasible solution. Thus, objective function must be maximized subject to the restrictions of the resource supplies and the condition that no activity level can be negative. The restriction prevents this occurrence, but its real purpose is to guarantee that the option does not require resources in excess of the amounts available (Earl O. Heady and Wilfred Candler,

1958). In addition, it is possible for us to use linear programming to capture the results of all changing of the available resources and prices. For these conveniences, linear programming will be applied here to analyze the problems of dairy farm management in the study areas.

Definition of variables, assumptions, coefficients and restrictions

Case of Hanoi

Considering a representative farmer in Hanoi with 4 family members (2 members are main labor), 4 *saos* of paddy land, 2 *saos* of alluvial land, 50 m^2 of barn (picture 1) and some working capital depending on amount and price of raw milk of every 10 days. There are 11 activities and the following 11 variables are introduced to show the corresponding activity levels.

X_1	Rotation 1 (Spring rice–Autumn rice)	(sao)
X_2	Rotation 2 (Spring rice–Autumn rice–winter maize)	(sao)
X_3	Rotation 3 (winter maize–spring maize)	(sao)
X_4	Rotation 4 (Grass on paddy land)	(sao)
X_5	Rotation 5 (Grass on alluvial land)	(sao)
X_6	Number of cows (Adult cow equivalent)	(head)
X_7	Corn buying	(100 *kg*)
X_8	Bran buying	(100 *kg*)
X_9	Green fodder buying	(100 *kg*)
X_{10}	Green fodder collecting by family labor	(100 *kg*)
X_{11}	Money borrowing	(thous. VND)

At present, the unemployment rate in the rural is quite high. Most of dairy farmers want to utilize their available labor force. A few farmers think about hiring labor. So, It is assumed that dairy households do not use the hired labor. It is also assumed that dairy farmers grow rice, maize and grass. Rice bran and corn are used as condensed feed to feed cows. Grass, rice straw and maize stalk are also utilized as fodder. They are all called intermediate products. Dairy farmers receive money from selling raw milk every ten days. This amount of money is considered as maximum working capital to buy extra needed corn, rice bran, green fodder and other agricultural inputs such as fertilizer, seed and paying interest for the borrowed investment capital.

The coefficients of objective function (OF) will be shown in the following tables. It is noted that all the coefficients are calculated regardless of family labor cost. If farmers do not grow rice, they have to buy paddy with the market price of VND 1,800 per *kg*. So, this price is used to estimate coefficient of rotation 1. With paddy yield of 310 *kg*/two crops (Hanoi Statistical office, 2002), farmers get VND 260 thousand (558–298) per sao per year (table 1). Rotation 1 also brings farmers 40 *kg* dried straw and 75 *kg* rice bran used as intermediate products. 1 *kg* dried straw is equivalent to 5 *kg* natural grass (Phung Vu, 2002)

Rotation 2 is equal to rotation 1 plus with winter maize. Additional intermediate products of the rotation 2 are 100 *kg* corn and 400 *kg* fresh stem at the harvesting time (picture 3,4). 1 *kg* fresh stem will be equivalent to 1 *kg* of natural grass (Phung Vu, 2002). Therefore, the coefficient of X_2 is equal to the coefficient of X_1 minus total material cost of winter maize (260-52=208) (table 2).

Table 1. Cost–benefit of rotation 1

Paddy price (VND/kg)	1800	Paddy yield (kg/sao/year)	310
		Return per sao (10^3VND)	**558**
Intermediate supply of products: 40 kg dried straw and 75 kg bran/sao per year			
Material costs (per sao)			
	Quantity (kg)	Price (VND)	Value (10^3 VND)
Seed	2	2160	4.32
Manure			10
Nitrogen	8	2300	18.4
Phosphorus	10	1100	11
Potassium	3	2500	7.5
Pesticide	1	7000	7
Herbicide	1	6000	6
Hired machine cost	1	50000	50
Irrigation cost	11	1800	19.8
Tax	8.28	1800	14.904
Total of the above material cost per crop			**149**
Total of the above material cost per sao per year			**298**

Source: survey 2002–2003

Table 2. Cost of winter maize

Corn yield (kg/sao/year)	100		
Intermediate supply of products	100 kg corn and 400 kg stem per sao per year		
Material costs			
	Quantity (kg)	Price (VND)	Amount (10^3VND)
Seed	0.5	3000	1.5
Manure			10
Nitrogen	2	2300	4.6
Phosphorus	10	1100	11
Potassium	2	2500	5
Pesticide		7000	0
Herbicide		6000	0
Hired machine cost	1	20000	20
Total of the above material cost			52

Source: Survey 2002–2003

Coefficient of rotation 3 is minus because all products of this rotation are intermediate products including 200 *kg* of corn and 800 *kg* of stem per *sao* per year (table 3)

Rotation four and five are grass. Grass yield per sao is about 12960 *kg* in average (Animal husbandry journal No. 7–2002). Farmers use only nitrogen for fertilizing grass after cutting, about 10 *kg* per *sao* per time. Coefficient of grass on paddy land is minus 245 (table 4) and coefficient of grass on alluvial land is minus 236 (table 5).

Coefficient of X_6 is total value of raw milk and calf per head per year after deducting cost for feeds bought 100% without use of intermediate supply such as soybean, brewery's by product, mineral and salt, and deducting average value for breeding and

Table 3. Cost of maize in alluvial land

Sold amount	Corn yield (kg/sao/year)		200
Intermediate supply of products: 200 kg corn and 800 kg stem per sao per year			
Material costs			
	Quantity (kg)	Price (VND)	Amount (10^3VND)
Seed	0.5	3000	1.5
Manure			10
Nitrogen	1	2300	2.3
Phosphorus	8	1100	8.8
Potassium	1	2500	2.5
Pesticide		7000	0
Herbicide		6000	0
Hired machine cost	1	20000	20
Tax	5.4	1800	9.72
Total of the above material cost			54.82
Total of the above material cost per sao per year			109.64
Coefficient for rotation 3			**-110**

Source: survey 2002–2003

Table 4. Cost of production of grass (X_4)

Grass yield (100 kg/sao/year)	130		
Intermediate supply of products	13000 kg grass per sao per year		
Material costs			
	Quantity (kg)	Price (VND)	Amount (10^3VND)
Seed			0
Manure			10
Nitrogen	90	2300	207
Tax	15.56	1800	28.008
Total of the above material cost per sao per year			245

Source: survey 2002–2003

Table 5. Cost of production of grass (X_5)

Grass yield (100 kg/sao/year)	130		
Intermediate supply of products	13000 kg grass per sao per year		
Material costs			
	Quantity (kg)	Price (VND)	Amount (10^3VND)
Seed			0
Manure			10
Nitrogen	90	2300	207
Tax	10.8	1800	19.44
Total of the above material cost per sao per year			236

Source: survey 2002–2003

Table 6. Return from one cow per year

Items	Total production (kg)	Intermidiate use (kg)	Sold amount (kg)	Price (VND/kg)	Return (10^3VND)
1. Raw milk	3965	200	3765	3000	11295
2. Male calf			0.5	5000000	2500
3. Female calf			0.5	5000000	2500
4. Manure			12	10000	120
Total					16415

Source: survey 2002–2003

Table 7. Cost of feed bought 100% per year

	Feed bought 100% in Phudong			
No Kinds of feed	Price VND/kg	Quantity kg/day	Total quality per period (kg)	Total value per year (VND)
Condensed feed				
1 Rice bran	1,500	2.05	625.25	
2 Corn	2,500	2.6	793.00	
3 Soybean	6,000	0.25	76.25	457500
4 Mixed bran	5,000		0.00	
5 Brewery's by product	600	5.6	1708.00	1024800
6 Molasses	1,500		0.00	
Roughage			0.00	
7 Green fodder	200	40	12200.00	
8 Dry fodder			0.00	
Others			0.00	
9 Mineral	10,000	0.05	18.25	182500
10 Salt	1,000	0.05	18.25	18250
Value of feed bought 100% without intermediate supply (thous. VND)				**1683**

Source: survey 2002–2003

Table 8. Other cost per cow per year

Items	Value (10^3VND)
Breeding and AI cost	100
Diseases and treatment cost	420
Other micellaneous cost	691
Sub total	1211

Source: survey 2002–2003

veterinary cost, miscellaneous cost and depreciation cost of cow. Costs for inputs with intermediate supply are considered otherwise through buying activities and resource restrictions.

Soybean, brewery's by–product, mineral and salt is bought 100%. Total cost of all these feed is VND 1,683,000 per year (table 7). For other cost like breeding, veterinary

and miscellaneous, farmer needs to pay about VND 1,211,000 per year (table 8). The cow depreciation cost is VND 2 millions per year. Estimated return per year from calf, manure and from raw milk after deducting 200 *kg* for calf is VND 16,415,000 (table 6). Income coefficient of dairy enterprise is **11521**=16415-1683-1211-2000.

Coefficients of X_7, X_8, X_9 are minus prices of corn, rice bran and green fodder per 100 *kg*, and corresponding prices are VND 2,500, VND 1,500 and VND 200 per *kg*. Coefficient of X_{10} (collecting grass) is minus 5 because it costs farmers about VND 5 thousand for fuel to go to collect grass (picture 5). Coefficient of minus 0.127 is minus interest rate per year farmers have to pay for borrowing money X_{11}.

Restrictions

The most 5 kinds of restriction, including land, shed, feed, family labor and capital, are considered in this model. The first two are land restrictions. Rotation one and two are applied only for 4 *saos* of paddy land. Rotation three is connected with 2 *saos* of alluvial land. Rotation four and five of grass are possible to be applied on paddy land and alluvial land, respectively. The third restriction is shed restriction. In average each household has a barn of 50 m^2 capacity. Restrictions on corn, rice bran and fodder are formed on the basis that needed amounts cannot be larger than available amounts, including intermediate product from activities 1, 2, 3, 4, 5 and 10. The next 12 restrictions are limitations on family labor for 12 months. The rest ones are restrictions of capital. Working capital restrictions for each of two seasons are based on costs and benefits used by farmers within 10 days. With respect to investment capital, at present, farmers in Phudong are borrowing VND 10 millions, in average, from various sources. The last two inequalities express restriction of borrowing capital, where total planed value of cow minus borrowing amount must be less or at least equal to total value of cows at present.

In the North, farmers work very hard and have less leisure time. They often work 10 hours a day. Table 9 shows workable days per month of a representative household with two main labors and two others being pupils working 4 hours a day with working ability of 0.5.

Table 9. Total workable days of farm management (one day=8 hours)

No. Items	1	2	3	4	5	6	7	8	9	10	11	12	Total
1 Days	23	23	25	25	25	25	23	23	25	25	25	23	290
Hours	230	230	250	250	250	250	230	230	250	250	250	230	2900
2 Days	23	20	25	25	25	25	23	23	25	25	25	23	287
Hours	230	200	250	250	250	250	230	230	250	250	250	230	2870
3 Days	8	8	8	8	8	8	8	8	8	8	8	8	96
Hours	16	16	16	16	16	16	16	16	16	16	16	16	192
4 Days	8	8	8	8	8	8	8	8	8	8	8	8	96
Hours	16	16	16	16	16	16	16	16	16	16	16	16	192
Total hour	492	462	532	532	532	532	492	492	532	532	532	492	6154
Day equivalent	61.5	57.8	66.5	66.5	66.5	66.5	61.5	61.5	66.5	66.5	66.5	61.5	769.25

Source: Survey 2002-2003

Where: Total workable days of farm management per month are calculated as follows.

Table 10. Labor input per unit activity (day)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Items												
Rotation 1												
Land preparation	2											
Transplanting(spreading)		2				1	1					
Weeding			2				2					
fertilization(Manure)								1				
Irrigation												
Pest control				1	1			1	1			
Harvesting						2				2		
subtotal	***2***	***2***	***2***	***1***	***1***	***3***	***3***	***2***	***1***	***2***	***0***	***0***
Rotation 2												
Land preparation	2					1	1			2		
Transplanting(spreading)		2					2				2	
Weeding			2					1				
fertilization(Manure)												
Irrigation											3	3
Pest control				1	1			1	1			
Harvesting	2					2				2		
subtotal	***4***	***2***	***2***	***1***	***1***	***3***	***3***	***2***	***1***	***4***	***5***	***3***
Rotation 3												
Land preparation			2							2		
Transplanting(spreading)				2							2	
Weeding												
fertilization(Manure)												
Irrigation				3	3						3	3
Pest control												
Harvesting	2				2							
subtotal	***2***	***0***	***2***	***5***	***5***	***0***	***0***	***0***	***0***	***2***	***5***	***3***
Rotation 4												
Land preparation		0.5	1.5									
Transplanting(spreading)			1.5									
fertilization(Manure)	1	0.5		1	1	1	1	1	1	1	1	1
Harvesting	1	0.5		1	1	1	1	1	1		1	
subtotal	***2***	***1.5***	***3***	***2***	***2***	***2***	***2***	***2***	***2***	***1***	***2***	***1***

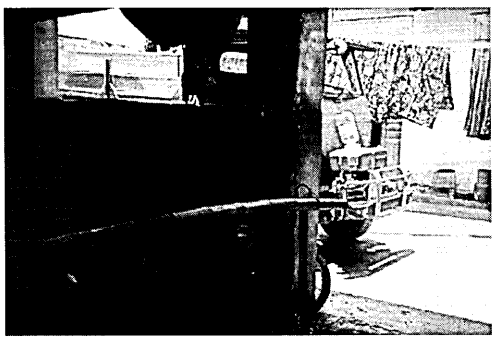
Source: Survey 2002–2003

$$\sum_{i=1}^{m} (ability)_i \times (day)_i$$

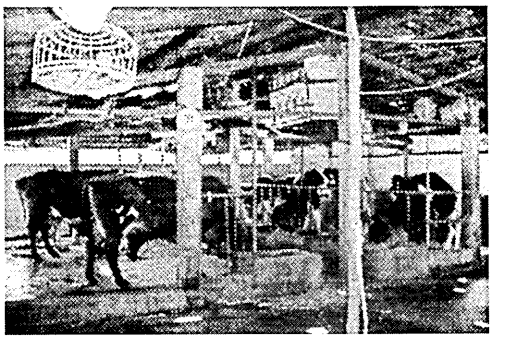
$(ability)i$ = working ability of the i–th person
$(day)i$ = working days per month of the i–th person

Basing on schedule of crop and climate condition, labor input per unit activity is calculated in the table 10. In average 10 labor–days (8 hours per day) will be needed for one sao of rice per crop. Each stage of rice producing, including land preparation, transplanting, weeding, pest control and harvesting, needs about 2 days. Winter maize crop is started in the middle of October and harvested in late January. Grass is often transplanted in the end of February and early March.

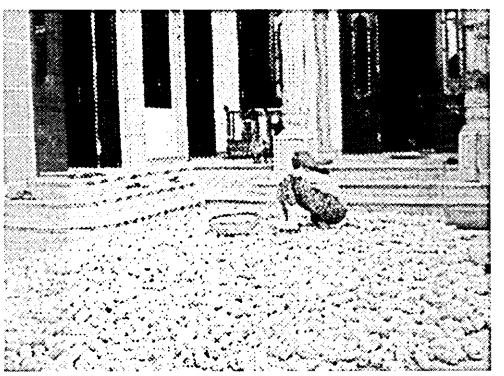
The problem for Hanoi case is to maximize the following objective function (OF) (unit: thousand VND):



Picture 1. Barn in Hanoi

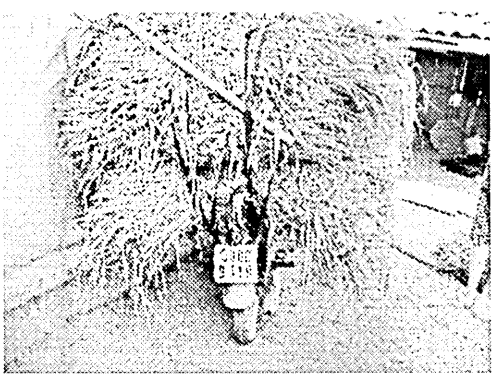


Picture 2. Barn in Hochiminh



Picture 3. Self–supplied corn in Hanoi

Picture 4. Collecting leaves of maize in Hanoi



Picture 5. Collecting wild grass

Picture 6. Grass grown in Hochiminh City

$OF = 260\,X_1 + 208X_2 - 110X_3 - 245X_4 - 236\,X_5 + 11521\,X_6 - 250\,X_7 - 150\,X_8 - 20\,X_9 - 5\,X_{10} - 0.127\,X_{11} - Fixed\ cost$

Subject to 22 restrictions as follow:

260	**208**	**−110**	**−245**	**−236**	**11521**	**−250**	**−150**	**−20**	**−5**	**−0.127**	**OF**	**Slack**
X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	**Res.**	**Var.**
1	1		1	0	0	0	0	0	0	0	**≤ 4**	X_{12}
0	0	1	0	1	0	0	0	0	0	0	**≤ 2**	X_{13}
0	0	0	0	0	7	0	0	0	0	0	**≤ 50**	X_{14}
0	−1	−2	0	0	8.38	−1	0	0	0	0	**≤ 0**	X_{15}
−0.75	−0.75	0	0	0	6.55	0	−1	0	0	0	**≤ 0**	X_{16}
−2	−6	−8	−130	−130	146	0	0	−1	−1	0	**≤ 0**	X_{17}
2	4	2	2	2	4	0	0	0	0.4	0	**≤ 61.5**	X_{18}
2	2	0	1.5	1.5	4	0	0	0	0.4	0	**≤ 57.8**	X_{19}
2	2	2	3	3	4	0	0	0	0.4	0	**≤ 66.5**	X_{20}
1	1	5	2	2	4	0	0	0	0.4	0	**≤ 66.5**	X_{21}
1	1	5	2	2	4	0	0	0	0.4	0	**≤ 66.5**	X_{22}
3	3	0	2	2	4	0	0	0	0.4	0	**≤ 66.5**	X_{23}
3	3	0	2	2	4	0	0	0	0.4	0	**≤ 61.5**	X_{24}
2	2	0	2	2	4	0	0	0	0.4	0	**≤ 61.5**	X_{25}
1	1	0	2	2	4	0	0	0	0.4	0	**≤ 66.5**	X_{26}
2	4	2	1	1	4	0	0	0	0.4	0	**≤ 66.5**	X_{27}
0	5	5	2	2	4	0	0	0	0.4	0	**≤ 66.5**	X_{28}
0	3	3	1	1	4	0	0	0	0.4	0	**≤ 61.5**	X_{29}
12.5	0	6	7	6.5	−390	7	4	0.55	0.014	0.003	**≤ 0**	X_{30}
0	16.7	6	7	6.5	−390	7	4	0.55	0.014	0.003	**≤ 0**	X_{31}
0	0	0	0	0	20000	0	0	0	0	−1	**≤60000**	X_{32}
0	0	0	0	0	0	0	0	0	0	1	**≤10000**	X_{33}

Case of Hochiminh city

Consider an average size household with 5 family members, 3 members are main labors, one is worker having two hours a day for dairy works, one works as small trader or retailer. This last member is often the wife of the household. She may help her husband for a half day. The husband of a household is often found to be household head and be responsible for dairy caring. So, total possible time for dairy farming in this household is around 14 hours a day, around 52.5 days/month in equivalent. Most dairy farmers in Tanxuan commune own 2000 m^2 of land (equal to 5.55 *saos*) and 150 m^2 of shed (picture 2). They can grow rice or pennisetum for green fodder on this area. Because grown grass is not enough, farmers usually buy straw with price of VND 1000 per *kg*, one *kg* of rice straw is equivalent to 5 *kg* of grass. Farmers receive money from selling milk every 7 days with milk price of VND 2700 per *kg*.

It is assumed that the household is keeping 6 lactating cows at present, equal to VND 120 millions. Average amount of borrowed money is VND 12.6 millions per household. With 6 activities, similar to the case of Hanoi, we got all coefficients for the objective function and restrictions as follow. It is note that intermediate supply of feed is considered only for fodder.

X_1 Number of cows (Adult cow equivalent) (head)

X_2	Grass growing	(sao)
X_3	Rice growing	(sao)
X_4	Green fodder buying	100 *kg*
X_5	Dried fodder buying	100 *kg*
X_6	Money borrowing	(thous. VND)

Depreciation cost of cow is VND 2 million, feed cost excluding only fodder cost is VND 4797 thousand (table 11) and other variable cost is VND 992 thousand (table 13), so income coefficient of dairy enterprise is 7497 (15286-4797-992-2000=7497).

Table 11. Cost of feed bought 100% per cow in Tanxuan

No	Kinds of feed	Price VND/kg	Quantity kg/day	Value (VND)	Value per year (10^3VND)
	Condensed feed				
1	Mixed bran	2,500	3	7,500	2287.5
2	Cassava residue	200	14	2,800	854
3	Brewery's by product	600	7	4200	1281
	Roughage				0
7	Green fodder		0	0	0
8	Dry fodder		0	0	0
	Others			0	0
9	Mineral	10,000	0.05	500	152.5
10	Salt	1,000	0.05	50	15.25
	Cost in lacta. period				4590
	Cost in dry period				207
	Total				**4797**

Source: Survey 2003

Table 12. Return per cow in Hochiminh

Items	Total production (kg)	Intermediate use (kg)	Sold amount (kg)	Price (VND/kg)	Return (10^3VND)
1. Raw milk	3965	200	3765	2700	10165.5
2. Male calf			0.5	5000000	2500
3. Female calf			0.5	5000000	2500
3. Manure			12	10000	120
Total					15286

Source: Survey 2003

Table 13. Other variable cost per cow in Hochiminh City

Items	Value (10^3VND)
Breeding and AI cost	200
Diseases and treatment cost	300
Other micellaneous cost	492
Total	992

Coefficient of variable X_2–grass grown–is as same as that of Hanoi (–245) (picture 6)

In Hochiminh City and the South there are three nominal crops per year, but in fact the crop intensity is only 2 (Hochiminh city statistical yearbook). Average paddy yield per *sao* per year is 227 *kg* (Hochiminh City Statistical Office, 2002). Price of paddy in the South is lower than that of the North, about VND 1500 per *kg*.

In the problem of dairy farming in Hochiminh City, 55 *kg* of bran per *sao* per year will be valued as a sold product at price of VND 1000 per *kg*. So, coefficient of X_3 is 168 (168=341+55-228) (table 14).

Table 14. Coefficient of X_3

Sold amount	227	Paddy yield (kg/sao/year)	227
Paddy price (VND/kg)	1500	Return per sao (10^3VND)	**341**
Intermediate supply of products: 40kg dried straw			
Material costs (per sao)			
	Quantity (kg)	Price (VND)	Value (10^3VND)
Seed	2	2160	4.32
Manure			10
Nitrogen	8	2300	18.4
Phosphorus	10	1100	11
Potassium	3	2500	7.5
Pesticide	1	7000	7
Herbicide	1	6000	6
Hired machine cost	1	50000	50
Irrigation cost	11	1800	19.8
Total of the above material cost per crop			**114**
Total of the above material cost per sao per year			**228**

Source: Survey 2002–2003

Table 15. Labor input per unit activity

Month	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Work processing												
Rotation of rice												
Land preparation	2					1	1					
Transplanting(spreading)		2					2					
Weeding			2					1				
fertilization(Manure)												
Irrigation												
Pest control				1	1			1	1			
Harvesting						2				2		
Subtotal	***2***	***2***	***2***	***1***	***1***	***3***	***3***	***2***	***1***	***2***	***0***	***0***
Rotation of grass												
Land preparation			1	2	1							
Transplanting(spreading)												
fertilization(Manure)	1	1	1	1	1	1	1	1	1	1	1	1
Harvesting	1		1		1	1	1	1	1	1	1	
Subtotal	***2***	***1***	***3***	***3***	***3***	***2***	***2***	***2***	***2***	***2***	***2***	***2***

Source: Survey 2003

Coefficients of X_4 and X_5 are minus prices of green fodder and dried fodder per hundredweight. They are minus 20 and minus 100, respectively. Coefficient of X_6 is minus interest rate per year of borrowing capital.

Labor input per unit activity of rice is about the same as that of Hanoi. But grass will be transplant at the beginning of rainy season–from the end of March to the early May.

The dairy farming problem of Hochiminh City is to maximize objective function: $OF = 7497X_1 - 217X_2 + 168X_3 - 20X_4 - 100X_5 - 0.127X_6 - Fixed\ cost$, subject to 11 restrictions.

There is only one restriction for land, one restriction for fodder and one for shed. There are 4 restrictions on family labor for 5 months, because each of restrictions on the other months is less restrictive or coincident with one of the 4 restrictions. The rest two

7497	**-245**	**168**	**-20**	**-100**	**-0.127**	**OF**	**Slack**
X_1	X_2	X_3	X_4	X_5	X_6	**Res.**	**Var.**
0	1	1	0	0		0 $\leq$ **5.55**	X_7
127.75	-129.6	-2	-1	-5		0 $\leq$ **0**	X_8
7	0	0	0	0		0 $\leq$ **150**	X_9
2.5	2	2	0	0		0 $\leq$ **52.5**	X_{10}
2.5	3	1	0	0		0 $\leq$ **52.5**	X_{11}
2.5	3	2	0	0		0 $\leq$ **52.5**	X_{12}
2.5	2	3	0	0		0 $\leq$ **52.5**	X_{13}
2.5	2	1	0	0		0 $\leq$ **52.5**	X_{14}
-153.7	7	12.5	0.38	2		0.003 $\leq$ **0**	X_{15}
20000	0	0	0	0		-1 $\leq$ **120000**	X_{16}
0	0	0	0	0		1 $\leq$ **12600**	X_{17}

are restrictions on working and investment capital.

The purpose of the model used is to give value of variables that maximize the objective function and shadow prices of all restrictive resources at certain conditions, but not to suggest a best way to reach that optimal plan. The later will be another problem.

Optimal farm plan

Firstly, the optimal dairy farm plans are found, corresponding to several discrete

Table 16. Result for the case of Hanoi

Cases	X_1 sao	X_2 sao	X_3 sao	X_4 sao	X_5 sao	X_6 head	X_7 100 kg	X_8 100 kg	X_9 100 kg	X_{10} 100 kg	X_{11} mill	OF +FC
Basis	0	3.38	0	0.62	2	3	21.76	17.12	0	76.86	0	26.25
Capital	0	2.17	0	1.83	2	4	31.35	24.57	0	72.91	20	31.19
borrowing is	0	0.96	0	3.04	2	5	40.94	32.03	0	68.95	40	36.12
200.10^6,	0	0	0	4	2	6	50.28	39.30	34.75	61.25	60	40.59
barn of 50 m^2	0	0	0	4	2	7	58.66	45.85	190.75	51.25	80	43.42
Unrestrictive	0	0	0	4	2	8	67.04	52.40	346.75	41.25	100	46.25
Barn and	0	0	0	4	2	9	75.42	58.95	502.75	31.25	120	49.09
Available	0	0	0	4	2	10	83.80	65.50	658.75	21.25	140	51.92
Capital	0	0	0	4	2	11	92.18	72.05	814.75	11.25	160	54.75
	0	0	0	4	2	12	100.6	78.60	970.75	1.25	180	57.58
	0	0	0.88	2.75	1.1	13	107.1	85.15	1388.2	0	200	56.00

defined resource restrictions and the same price situation mentioned above, as shown in the table 16. If a household raises 3 heads, they should use 2.62 *saos* of land for growing grass and keep 3.38 *saos* for rotation 2 of spring rice, autumn rice plus winter maize. With an increase of borrowing restriction of investment capital, the model suggests that farmer should invest in buying more cows and grow more grass instead of rice on paddy land. Farmer should leave only 0.96 *sao* of paddy land for rice if he owns 5 heads. However, with a more than 5 heads, farmer should use all of the land resource for growing grass. He also has to buy fodder to save time to spend on caring cows instead of collecting natural grass. The more cows a farmer raises, the less amount of wild grass he can collect and the more money he has to spend on buying fodder.

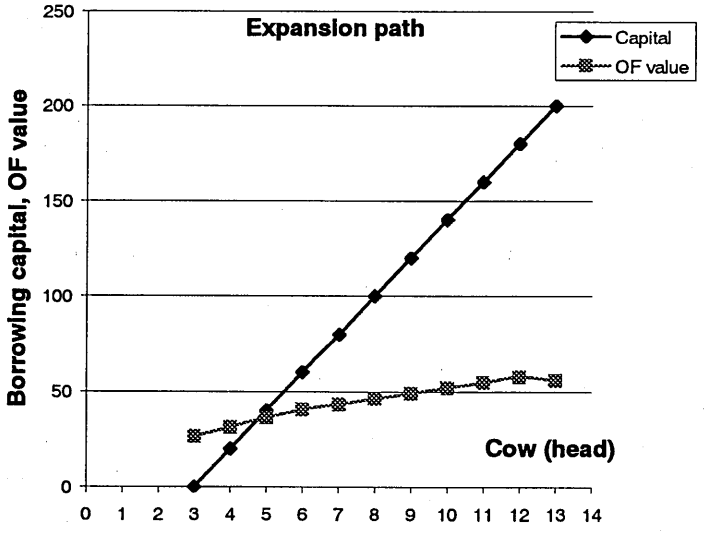


Fig. 1. Expansion path of dairy farming in Hanoi

Table 17. Result for case of Hochiminh city

Cases	X_1 head	X_2 sao	X_3 sao	X_4 100 kg	X_5 100 kg	X_6 (mill.)	OF+FC (mill.)
Basis	6	5.55	0	0	9.00	0	42.87
Available	8	5.55	0	0	60.10	40	47.68
capital	10	5.55	0	0	111.2	80	52.48
barn of	12	5.55	0	0	162.3	120	57.29
150 m^2	14	5.55	0	0	213.4	160	62.09
	15	5.00	0	0	253.25	180	63.18
	16	4.16	0	0	300.47	200	63.60
	18	2.50	0	0	394.90	240	64.43
	20	0.83	0	0	489.33	280	65.26
	21	0	0	0	536.5	300	65.68

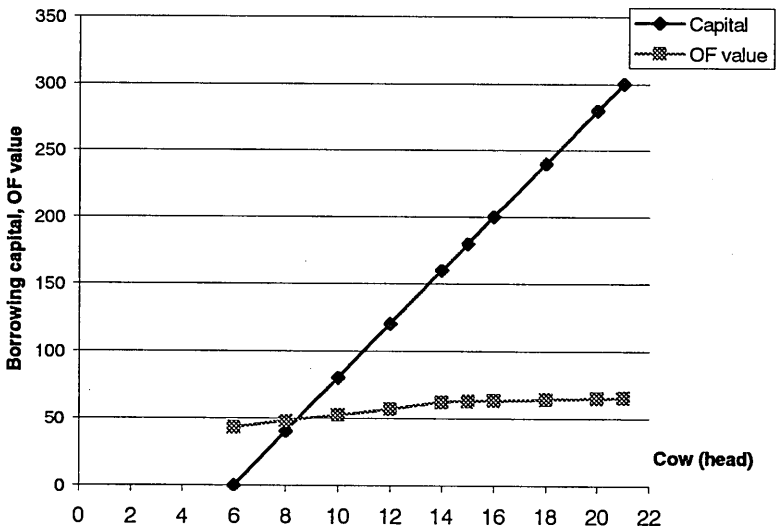


Fig. 2. Expansion path of dairy farming in Hochiminh City

With assumptions that investment capital is available as much as needed at 1%–interest rate per month and land and family labor are fixed and unchangeable, optimal dairy farm size will be 7 heads if household owns a shed of only 50 m^2 of capacity. Without shed restriction, optimal dairy farm size will be 12 heads (Table 16).

In the case of Hochiminh City, the result shows that all of land resource should be used for growing grass. Shadow price of land is VND 2,383,000 per *sao* if the dairy farm size is not larger than 14 heads. After that, suggested area of land for grass growing is getting smaller because family labor becomes restrictive at the shadow price around from VND 794,000 to VND 960,000 per man–day per month. In reality, all land will be used. Dairy farmers may either change their preference of leisure time and work harder or they use hired labor. Optimal size of dairy farming is 21 heads with unchanged labor resource and without limitation on capital (table 17).

Factors affecting the optimal plan of dairy farming in Hanoi and HCM city

Capital is a decisive factor affecting dairy farm size in both Hanoi and Hochiminh City. To buy an additional cow farmer needs at least VND 20 millions and to get to the optimal size suggested above farmer will have to borrow nearly VND 200 millions in Phudong and about VND 300 millions in Tanxuan. However, it is really difficult for dairy farmers to access such a big amount of capital.

The factor shed is an obstacle preventing enlarging of dairy farm size in Hanoi. If cows are kept inside their resident land, the maximal cow number they can raise is 7 heads. They have to move the barn to any other possible place for a bigger size than that.

Without restrictions on investment capital and shed and holding other resources constant, family labor force is only able to manage maximal 12 heads in Hanoi and 15 heads in

Hochiminh city. Unless dairy farmers use hired labor or use labor–saving– technologies, the dairy farm size is very small.

Land is always the restrictive resource. The shadow prices per sao of paddy land and alluvial land are VND 594,438 and VND 603,438, respectively, if number of cows is less than 6 head. It means that an additional *sao* of land could bring farmers an income equaling to shadow price. The land resource becomes more and more restrictive for the larger dairy farm size. This shadow price of land will be up to around VND 2,250,000. It suggests a potential trend of transferring rice–cultivated land to grass–grown land.

Milk price is kept steady for a long period. At present, according to Government's regulation, milk price at factory gate is set not to be lower than VND 3550 per *kg* if milk criteria are met. So if there is any thing happens to milk price, then it must be an increasing of milk price. With assumption of barn of 150 m^2 and available capital at VND 300 millions and holding others, this increasing only makes the value of objective function increased if milk price is lower than VND 3,800 per *kg* at farm gate in Phudong. However, the optimal size of dairy farm here will be suggested at 14 heads if farm gate price is increased to VND 4,000 *kg*. At this point, suppose that farmers prefer less leisure or hire more labors to make labor source double than present, the optimal dairy farm size will reach 18 heads and the value of objective function is very high because all the available land is used to grow grass. In the case of Hochiminh City, even though milk price received by farmers rises to VND 3,700, the optimal dairy farm size is still unchanged, 21 heads. But the figure is 26 per farm if household spends about 12 man–days/month more on dairy farming.

In Phudong, feed price changed at an acceptable higher level does not affect the optimal size in terms of number of cows but remarkably reduces the value of objective function. For instant, if condensed feed price increasing about VND 1,000 per *kg* (VND 3,500 per *kg* of corn and VND 2,500 per *kg* of rice bran), then the optimal dairy farm sizes are the same but value of objective function is about two third compared to the case of present prices. Keeping the condensed feed prices at the above levels and increasing price of fodder at VND 300 per *kg*, the same results are achieved: the same optimal dairy farm size and decreased value of objective function. Unlike the problem of Phudong, in Tanxuan feed prices have a strong effect on farm size. The results suggests that farmers here should keep only 14 heads per household if price if mixed bran, cassava residue and brewery's by–product increases 20%, 50% and 30%, respectively. The same conclusion is found if price of fodder alone increase 50%. The optimal dairy farm size in Tanxuan is only 6 heads if both prices of condensed feed and fodder are changed with the above amounts.

Conclusion

As analyzed above, average dairy farm size in Hanoi and Hochiminh city have not been optimal ones. With current production conditions and family labor force, number of cows at the optimal level will be 4 times higher than present size in Hanoi and more than triple in Hochiminh city. That is the reason made income of dairy households have not been maximized yet. There are several limiting factors should be simultaneously improved in order to increase number of cows in each household.

All services from production to consumption should be available to support farmers in

dairy farming. The households, who cannot raise cows, should be encouraged by the local government to grow grass and sell to dairy households because grass enterprise has higher income than rice enterprise at current prices. Further assistances should be given to farmers who want to develop a farming model where large scale of cow herd is applied. This kind of model, at first, will absorb unemployment force in the rural area, and later, will be good places for trying and applying new technologies in dairy production.

The governments at various levels should help farmers accessing to credit in many different ways, such as simplifying procedures, increasing loan amount with longer duration and low interest rate. Farmers should actively seek credit for themselves. Cooperation between milk factories and dairy farmers is one measure to harmonize demand and supply of raw milk. Through a contract, dairy farmers can borrow money from milk factory and can pay back by raw milk.

Master plan of land use should be revised as soon as possible. We should facilitate dairy farmers to freely grow grass on their allocated land without any complaining from rice-growing farmers. Many people will be willing to invest more in dairy production if they have opportunities to cultivate grass instead of rice. In the communes like Phudong, resident land is very limited; the local governments should plan to move cow herd to separated place far from the resident areas. This plan will help reducing environmental pollution and easily enlarging number of cow without restraint of shed. In other commune, such a plan of land use should be made before introducing dairy production to avoid severe dilemma and unnecessary cost.

At the initial stage, subsidy policies are needed to increase output prices and lower input prices. There are some ways to target the goal. Government may directly assist milk companies to buy raw milk from dairy farmers at a higher price. The same policy may be applied to the livestock feed companies in order to loose tension on feed cost for dairy farmers. It is also possible to reach the target through dairy cooperatives. A strong dairy cooperative with an active management board and a potentially effective strategy will incorporate all dairy farmers. By covering all input and output services, cooperative will get higher diversity return and then will reduce, as much as possible, service's cost for their members.

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