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Energy of a dairy farm in a village dairy cooperative in the Tarai area of Uttaranchal Himalayas

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Abstract

Energy flow pattern in a dairy farm in a village dairy cooperative (VDC) in the Tarai area of Uttaranchal Himalayas was quantitatively analysed. Feed contributed as much as 73 % of the total energy flow. Of the total output energy, dung accounted for as much as 70 % and milk 30 % negligible amount of energy (only 0.1 %) was contained in the newborn calves. The energy balance of a dairy farm suggests that dung is the most important product of a dairy farm. Though milk is regarded as the most important product and virtually the only target of dairy production, dung is the largest proportion other dairy outputs of a dairy farm. Gross energetic efficiency of dairy farm in a VDC comes out to be 37 %. This would suggest that a dairy farm is able to efficiently utilize only 37 % of the energy and the rest 63 % is being used for purposes other than production. Energetic efficiency is an important indicator to measure the performance of a dairy farm in relation to the environment or the farming system it operates in. improvement in dairy farming efficiency will take place with the increase in outputs relative to inputs. Improvement in the productivity of the ecosystem a dairy farm is a part of will have impact on the performance of a dairy farm. Dairy farm linkages with the farming system components especially with households and cropland in the context of the Tarai area-need to be ameliorated so that the energy low pattern in the ecosystem/farming system is maintained in a way that should lead to enhance productivity of the system.

Key word: Dairy farm, Energetics, Energetic efficiency, Inputs, Outputs, Village dairy cooperative (VDC)

Introductoin

A dairy farm has linkages with the ecosystem it functions in. It receives energy from the ecosystem in the form of feed and fodder, uses as proportion of this energy for, maintenance and converts the rest into useful products and functions, e.g. calves milk, dung or manure, draught power, etc. In return to the inputs (feed) received from the ecosystem it is in continuous interaction with, a dairy farm, thus, gives valuable outputs and services to the ecosystem.Determination of gross energetic efficiency, or the output- input ratio, is the logical and objective method of evaluating the productive performance of a dairy farm as well as its linkages with the environment. Based on their long-term systematic study in temperate Himalayan environment, Singh and Sharma (1993) have proved its validity. Common denominator to which the input and output can be related with most accuracy is not economics, but energetic. The economic value of parameters involved tends to fluctuate with supply and demand. The calorific values remain relatively constant.

Energetics being dependent on the inputs and outputs of a dairy farm is a useful indicator to suggest whether a dairy farm, like any other components of a farming system, is sustainable or not. This is therefore, an important issue relating to the performance of a dairy farm, which helps to understand the basic relationship of the production system with its environment.

Materials and Methods

The study area falls in the Tarai of the Indian Central Himalayas- the Indian State of Uttaranchal. Udham Singh Nagar district in the Tarai of Uttaranchal in which the study villages are located is one of the 13

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districts of Uttaranchal. This district is situated towards the south of Uttaranchal bordering the Uttar Pradesh. This Tarai district of Uttaranchal is spread over a geographic area of 3055 km^2. Of the total population of the district , 68 % comprises the rural population. There are 687 inhabited villages in the district. Agriculture (including animal husbandry) is the main occupation in rural areas.

Six villages, which were the members of the District Milk Union Ltd, the Village Dairy Cooperatives (VDCs) in the Community Development Block (CDB) of Rudrapur in the Udham Singh Nagar district, were selected purposely. Situated on the outskirts of the GB Pant Univ. of Agriculture and Technology, the selected villages were: Anandpur, Raghav Nagar, Pratapur, Kanakpur, Shantipuri (No.1), and Jawahar Nagar.

The primary information was collected on the pre- structured proformas. Information was collected on VDC basis, as well as on individual farm basis in each VDC. From each VDC , 10 % of the total dairy farm were selected randomly for the collection of desired information.

Feed and fodder consumption by all the animals at a dairy farm and milk and dung production were recorded in sample families. Weighing of some samples on daily basis at some sample families gave average values for these inputs and outputs. Records of calf crop of livestock population were obtained through survey.

All the inputs and outputs were expressed on their dry matter basis. The dry-matter was determined in the laboratory at the animal science department. The energetic value of dry manure was considered to be 2.12 kcal per g (National Council of Applied Economic Research 1965).

To calculate feed consumption, amount of feed given to an animal was subtracted from the leftover feed. Energetic value of a particular feed item was calculated according to its fat, protein, and carbohydrate contents using available proximate analysis data from appropriate sources. Adding up the values of the individual nutrients, i.e., fat, protein, and carbohydrate determined the total energetic value of the feed items.

Energy value of milk was based on its fat content. Total calves born in a year were enumerated. Energetic value of a newborn cow calf is 21,387 kcal (Oden'hal 1972). Multiplying total number of calves born at a dairy farm during the year by this figure will give the total energetic value of cattle calf crop. Energy value of a buffalo calf is adjustéd to the approximate weight difference. A buffalo's body weight in the area is approximately 1.25 times higher than that of a crossbred cow. The same factor was used for evaluating energy value for a buffalo calf, which is equal to 26,736.25 kcal. Multiplying total number of buffalo calves at a dairy farm in a period of one year by this energy value will give energetic value for the buffalo calf crop at a dairy farm.

Results and Discussion

Size of dairy farm

Livestock holding size (No. of livestock per dairy farm) was rather small (2.87). About 78 % of the total livestock were cattle. There was no adult male in the herd that indicated the preference of milch animals in the herd. The Himalayan Tarai area depends, almost exclusively, on tractors and other machinery for agricultural operations. Absence of the draught animals from the herd, therefore, could be expected. There, however, male calves in the young stock. They were sold to the outsiders before they grew into adult work animals. Size of the animals in milk per dairy farm was still smaller dry-(1.04) (Table 1).

One reason of small herd size is the high-yielding breeds of dairy animals. Almost all the cows the herd were crossbreds with blood of Jersey and/ or Holstein-Friesian. Most of the buffaloes in the VDCs were Murrah. Few seemed to be admixture of Murrah and Bhadawari or other Indian breed. The other reason of the small herd size is Tarai farmers' concentration on cropping rather than on animal husbandry. Shortage of home labour spends much of the time and energy on crop farming. Since, milk is an indispensable item for

Table 1: Some important dairy farm indicators in the selected VDCs

Village dairy cooperative	Total no. of dairy farms	Dairy farms selected for study	Livestock per dairy farm			Animals in milk per dairy farm		
			Cattle	Buffaloes	Total	Cows	Buffaloes	Total
Anandpur	45	9	2.76	0.45	3.21	0.66	0.06	0.72
Raghav Nagar	110	22	2.25	0.38	2.63	0.90	0.13	1.03
Pratappur	100	20	3.00	0.23	3.23	1.00	0.08	1.08
Kanakpur	100	20	0.75	0.67	1.42	0.25	0.25	0.50
Shantipuri	170	34	1.98	0.83	2.81	0.88	0.29	1.17
Jawahar Nagar	150	30	2.86	1.12	3.98	1.33	0.46	1.79
Overall	675	135	2.26	0.61	2.87	0.83	0.21	1.04

Note: All figures except for dairy farms, total as well as selected for study, are averages per dairy farm family consumption, dairy farming too would go in hand with crop production. The plus point to a dairy farm in a VDC is gets marketing facility at the doorstep.

Dairy farm inputs

Green fodder, crop residues, and green grass are the main feeds that are harvested from the agro-ecosystem for livestock feeding. Concentrate feed is purchased from the market. Often cooperative provides 'Parag' brand concentrate to its members in the VDCs. Cost of the concentrate is deducted from the cost of the milk farmers sell to the society. Thus the green and dry fodder is the dairy input from within the system while concentrate feed is an external input. Out of the inputs from within the agro-ecosystem, green fodder (lucerne, oat, sorghum, maize, and sugarcane tops) is cultivated, whereas green grass grows wild and is extracted from the fields or uncultivated land during rainy season. By-products (crop residues) of food grain crops-wheat and rich-make the dry fodder.

Table 2: Dry-matter of different feed items consumed at a dairy farm in a year

Feed items	Dry-matter consumption (kg)
Wheat straw	1972.00
Rice straw	1459.00
Green fodder	
Berseem	800.00
Lucerne	400.00
Oat	400.00
Sorghum	1400.00
Maize	400.00
Sugarcane tops	400.00
Grass	200.00
Concentrate	602.00
Total	8033.00

The other basic input in a dairy farm is human labour. But that is not taken into consideration, as only the inputs in the form of biomass are taken into account for the purpose of study.

Daily feed consumed by individual dairy animals at the selected dairy farms in the study villages was closely observed for 18 weeks. Fodder calendar (feeding schedule) for the entire year was recorded in consultation with individual farmers that helped estimate feed consumption figures for the whole year. Amount of concentrate fed to the animals was equal to the amount of concentrate purchased during the year. The consumption figures were adjusted on dry-matter basis based on the determination of moisture/ dry-matter of some feed samples.

A perusal of Table 2 reveals that animals on a dairy farm, on an average, consume 8033 kg of dry-matter of feed, which is composed of 1972 kg wheat straw, 1459 kg rice straw, 4000 kg green fodder, and 602 kg concentrate in a period of 1 year. Green fodder comprises about 20 % berseem , 10% lucerne , 10% oat , 35% sorghum , 10 maize , 10 % sugarcane tops , and 5% grasses . Study was undertaken to assess the energy use pattern in cow milk production based on the primary data collected from sixty dairy farmers from Kancheepuram district of Tamil Nadu. The results revealed that the highest input energy per animal per day was noticed. Of all the input energy components, green fodder occupied a major share (61.92%), followed by concentrate (23.49%), on an average different size farm like (small, medium & large), Divya *et. al*.(2012).

Energy values of the feed were based on the carbohydrate, protein and fat contents of the feed items (on dry-matter basis) consumed by animals at dairy farms. Composition of these nutrients in feed sources (Table 3) was based on Arora (1997).

Table 3: Chemical composition (%) of feed sources consumed at a dairy farm in VDCs

Feed Source	Crude Protein	Crude fibre	Nitrogen-fre eextracts	Ether extracts
Wheat straw	3.81	37.50	46.51	0.00
Rice straw	2.40	36.49	43.74	0.87
Green fodder				
Berseem	15.45	26.06	35.88	2.36
Lucerne	19.90	29.61	34.68	1.81
Oat	9.90	26.60	50.50	2.22
Sorghum	7.75	32.30	49.61	1.73
Maize	6.74	35.95	47.07	2.09
Sugarcane tops	5.47	37.18	49.78	1.48
Grass	5.61	41.61	43.38	1.40
Concentrate	25.62	7.00	40.87	3.14

Total dry matter of different nutrients consumed by dairy animals at a dairy farm, based on total dry matter of different feed sources and their chemical composition, is presented in Table 4.

The energetic values of these nutrients are: crude protein= 5.56 kcal, crude fibre and nitrogen-free extract= 4.15 kcal, and ether extractives= 9.40 kcal/g (National Academy of Science-National Research Council 1996). The amount of individual nutrients multiplied by their respective energetic values gives energy intake (Table 5).

Table 4: Annual consumption of different nutrients (g) at a dairy farm

Feed Items	Crude Protein	Crude fibre	Nitrogen-fre eextracts	Ether extracts
Wheat straw	75133	739500	917177	0
Rice straw	35016	532389	634519	12693
Green fodder				
Berseem	123600	208480	287040	18880
Lucerne	79600	118440	138720	7240
Oat	39600	106400	202000	8880
Sorghum	108500	452200	694540	24220
Maize	26960	143800	188280	8360
Sugarcane tops	21880	148720	199120	5920
Grass	11220	83220	86780	2800
Concentrate	154232	42140	246037	18903
Total	675741	2575289	3594213	107896

Table 5: Annual energy consumption at a dairy farm

Nutrients	Dry weight (g)	Energy value, kcal
Crude protein	675741	375119.96
Crude fibre	2575289	10687449.35
Nitrogen-free extract	3594213	14915983.95
Ether extract	107893	1014222.40
Total	6953139	30374775.66

Animals at a dairy farm in a VDC, thus, consume 30,374,775.66 kcal in a year. Half of the total energy consumed during a year comes from nitrogen-free extracts. The other major source of energy is crude fibre that provides 35% energy. Total carbohydrates, thus, contribute as much as 85% energy. Crude protein contributes 12% of the total energy consumed while ether extract share only 3% energy.

Dairy farm outputs

Milk, dung/manure, and calf crop are the main outputs of a dairy farm. Though only milk is considered for economic evaluation of a dairy farm, dung and calves are also of great socioeconomic importance. Meat production from a dairy farm is never imagined. Dairy farming in the Tarai area, as in most of the Indian region, carries a notion of sacredness. Cows are especially sacred. Animals have positive interaction with the environment. Their role in maintaining cyclic flow-pattern of nutrients is vital for the productivity of the agro-ecosystem they are part of. An agro-ecosystem would have a defined boundary, involving uncultivated forest/grassland area and that the cultivated (cropland) area a dairy farm would have linkages with. A dairy farm has many intangible attributes also to its owner. Dairy animals are also a source of social and cultural prestige.

Milk

Daily milk production was recorded at selected dairy farms in the VDCs covered for survey for about 3 months. Annual estimates of milk production were based on producer's interview as well as on the official records maintained by VDC officials. Average percentage of fat in milk was approximately 4.5. One kilogram of4.5 % fat milk is equal to 794 kcal (Odend'hal 1972). Multiplying total annual average milk production (in kg) by 794 kcal gave the annual output of milk in terms of calories. Average annual milk production per dairy farm in the VDCs was 4319.78 kg, which is equivalent to 3429,905.32 kcal.

Dung

Dung voided by animals at dairy farm was weighed for 18 weeks on daily basis. The per day average gave figures for annual dung production at a dairy farm. Fresh weight of dung was converted into dry-matter after evaluating moisture content in few dung samples. Amount of dry dung was converted into its energy value, i.e. 2.13 kcal per g (National Council of Applied Animal Research 1965).

Average daily dung production on dry-matter basis at a dairy farm was 10.04 kg. This amounts to annual production of 3664.60 kg dry matter of dung per dairy farm. Energy value of this valuable dairy produce is equivalent to 7805,598 kcal.

Calves

Total calves born in a year were enumerated. Energetic value of a newborn cow calf is 21,387 kcal (Odend'hal 1972) Multiplying total number of calves born at a dairy farm during a year by this figure gave the total energetic value of cattle calf crop. Energy value of a buffalo calf is adjusted to the approximate weight difference.

A buffalo's body weight in the area is approximately 1.25 time higher than that of a crossbred cow. The same factor was used for evaluating energy value for a buffalo calf, which is equal to 26,736.25 kcal. Multiplying total number of buffalo calves at a dairy farm born in the period of 1 year by this energy value will give energetic value for the buffalo calf crop at a dairy farm.

At a dairy farm, on an average, 0.57 cow calf and 0.08 buffalo calf are added annually to the herd. Total energetic value of calf per dairy farm works out to be 14,330.63 kcal. Energy values of cow and buffalo calf are 12,191.73 kcal and 2138.90 kcal respectively

(Table 6).

Table 6: Energy value of calf crop at a dairy farm

Dairy animal	No. of calves born during the year	Energy value, kcal of a calf	Energy value, kcal
Cow	0.57	21389.00	12191.73
Buffalo	0.08	26736.25	2138.90
Total	0.65	48125.25	14330.63

Energy balance

An energy balance sheet (Table 7) for a dairy farm in a VDC presents total input and output energy values. We find that input energy in a dairy farm is much more than the total output energy. Dung contributes the highest output energy (7.81x 10^6), this value being more than 2 times higher compared to the energy flow through milk (3.43x10^6 kcal). A fraction of energy (0.01x 10^6kcal) flows through calf crop.

Table 7: The energy balance sheet of a dairy farm

Particulars	Energy value, kcal	Energy value, kcal (x10^6)
Input	30374775.66	30.37
Outputs		
Milk	3429905.32	3.43
Dung	7805598.00	7.81
Calves	14330.63	0.01
Total outputs	1124983.95	11.25

Of the total energy flow involved in a dairy farm, 73 % is input energy. Of the total output energy, dung accounts for as much as 70% and milk 30 %. Negligible amount of energy (only 1%) is contained in the newborn calves. The energy balance of a dairy farm suggests that dung is the most important product of a dairy farm. Though milk is regarded as the most important product and virtually the only target of dairy production, dung is the largest proportion of the production of a dairy farm.

The input energy is derived from the agro-ecosystem. A fraction of it (concentrate feed energy) flows through market system, though that too is a product of agro-ecosystem. Energy in dung (not used as fuel) returns to the soil, a component of the agro-ecosystem. Humans consume milk energy; calves also consume a fraction of it. Newborn calves retain a proportion of the output energy. The input and output energy ultimately keeps flowing within the ecosystem that comprises all the parts/components of a farming system, from where the input energy comes and in which the output energy circulates.

Gross energetic efficiency

Gross energetic efficiency is the percentage of the ratio of the total output energy, i.e. the calories derived from dairy animals having direct value for humans (e.g. milk for consumption and calves for sale or further production) and their ecosystem (e.g. dung or manure for soil fertility maintenance), to the input energy, i.e. calories of total feed consumption by dairy animals. In case of a dairy farm in the selected VDCs in the Tarai area of the Himalayas, it becomes clear from Table 8.

Table 8: Gross energetic efficiency of a dairy farm

Particulers	Values
Output energy, kcal (× 10^6)	11.25
Input energy, kcal (× 10^6)	30.37
Gross energetic efficiency, (%)	37.04
Energy for maintenance and growth, kcal (× 10^6)*	19.12

*Also through loses heat and gases

Chizonda, (2015) compare energetic inputs, outputs, and efficiencies of dairy farms in Malawi (Southeast Africa) and North Carolina to assess sustainable milk production. Feed energy intake was 359 MJ/cow/d at NCSU and 427 MJ/cow/d at Katete. The energy efficiency of milk production for the farm was 0.66 MJ. MJ-1 at NCSU and 0.07 MJ. MJ-1 in the lower producing cows at Katete. Which shows the dairy production that should be considered to improve efficiency, sustainability and milk supply. Both farms had a substantial portion of the energy fed to the cows lost to the environment as composted manure in soils are different to Himalayan ecosystem.

Gross energetic efficiency of a dairy farm in a VDC comes out to be 37 %. This would suggest that a dairy farm is able to efficiently utilize only 37 % of energy and the rest 63 % is being used for purposes other than production, including maintenance and growth. This would also infer that for unit calorie of production, as many as 2.70 calories are used.

The individual energy intake figures at a dairy farm are considerably higher than the figures provided by Odend'hal (1972) for rural West Bengal area. The cattle population covered in that study was composed of small sized indigenous breeds. In our case, most of dairy cattle population comprised crossbred cows with considerably higher body weight. Again dairy animal population comprised buffaloes, which are also of heavy weight. Rates of feed consumption primarily depend on body weight of individual animal. This principle is attributable to higher consumption figures at dairy farms studied.

The energetic efficiency of dairy animals in the Tarai area is considerably higher than of the crossbred dairy cattle reared in the temperate environment of the Himalayas where the energetic efficiency is only 18%. In the latter, considerable amount of energy comes from the forest area, as leaf fodder. High-energy crossbred animal husbandry in the Himalayan areas does not fare well because of non-availability of high quality green fodder unlike in the Tarai areas where all requirements of the animals are almost fulfilled.

Milk is the output of immediate human use. The crossbred cows and buffaloes are reared for milk production almost exclusively. This is evident from the absence adult male animals of these dairy animals. Adult male cattle are overwhelmingly used for draught purposes in many areas, like the hills of Uttaranchal.

The Tarai area, which is famous for the success of green revolution, uses tractors and other machinery in agriculture. Use of draught animal power (DAP) in farming in this area, at least in the highly patronized pockets like the ones studied, is rare. Male cow calves are sold to traders who take them to other areas where they have role to play. The energetic efficiency of a dairy farm would have gone down considerably had the farm had large proportion of non-dairy animals in the herd.

In a mixed crop-livestock farming system, dung is another important output of a dairy farm. Dung used as fuel is more efficient for cooking purposes since it burns slower and with a more even heat distribution and so it contributes to immediate human benefit (Odend'hal 1972). In plain areas, most of the dung produced was being used for cooking purpose until a few years ago when use of cooking gas (LPG) at farm households was a rare scenario. Now, with increasing consumption of LPG in rural areas of Tarai, most of the dung to (converted into manure) flows to cropland. Use of dung to fertilize the soil is vital for improving the productivity of the farming system. Its use as fuel in houscholds, however, cheap and efficient it might be, is a heavy tax on environment, for its entire energy is lost in the form of heat with no contribution to the improvement in the productivity of the farming system.

Energy for maintenance and growth of animals at a dairy farm-the difference between energy of consumption and of production- is equal to 19.12 ($x10^6$) kcal. A proportion of this energy would be lost through heat and gases.

Energetic efficiency is an important indicator to measure the performance of a dairy farm in relation to the agro- ecosystem or the farming system it operates in. There has been a dearth of studies on this aspect. No conservative estimate can, therefore, be made to conclude whether the energetic efficiency figure obtained through this study is satisfactory or not and to what extent. More work on this neglected aspect would help us in this direction and in evolving strategies for sustainable dairy farming in an environment.

Substantial improvement in dairy farming efficiency can take place with the increase in outputs relative to inputs. Improvement in the productivity of environment will have impact on the performance of a dairy farm. Dairy farm linkages with the farming system components especially with households and cropland in the context of the Tarai-area-need to be strengthened so that the energy flow pattern mediated through dairy farms in the ecosystem/farming system is maintained to the enhancement of productivity of the overall system.

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