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The Review of Agricultural Economics

A Technological and Business-management Study of Sustainable Agriculture, with a Focus on Hokkaido Dairy Farming

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Summary

Dairy farming that relies on purchased concentrate feed and that seeks herd expansion and high per-head milk yield produces frequent occurrences of sick cattle, overwork of farmers and environmental degradation. The government, in response to these problems, established the Law on Promoting Proper Management and Use of Livestock Excreta and also initiated efforts to increase the self-sufficiency rate of feed in the nation. Specifically, the measures include the establishment of livestock excreta treatment facilities, support for the cultivation of whole crop silage as a crop-switching measure and encouragement of the use of grass. However, full-fledged implementation of such measures has not yet been seen, due to the financial burden these measures have on farmers and the unprofitable nature of growing feed grains.

On the other hand, the following innovative attempts by farmers have recently attracted attention as management forms that are feasible even for small-scale, family-run farms : grazing as a laborsaving and low-cost technique ; "self-paced dairy farming," in which the management scale that is only sufficient to secure the self-supply of own coarse feed is maintained ; and organic-milk production, in which all livestock excreta are composted or applied to farm fields.

This paper, while reviewing the problems dairy farming in Hokkaido currently faces, discusses the livestock-related technical and management characteristics that can alleviate such problems. The following three conclusions were reached : First, sustainable dairy farming relies on the maximum self－supply of feed, which requires the reevaluation and use of local feed resources ; Second, sustainable livestock husbandry depends on small-scale, family－run farms, therefore, the development and dissemination of technologies that suit such farming forms are needed ; and Third, since the efforts to achieve sustainable livestock husbandry are permeated into society through the provision of safe food, it is crucial to establish the system and the distribution arrangements that allow information sharing between producers and consumers.

1. Introduction

Hokkaido dairy farmers run their operations under a price system in which gross income rises with the milk production and full cream milk solids (butterfat plus solids not fat). Assuming that milk components are constant, the number of a farmer's cows and the individual capacity (milk yield per head) will determine income. For that reason dairy farmers now choose livestock management techniques that seek to improve per-head milk yield through technological means, and that has resulted in the current "processing type" of dairy farming that is dependent on imported feed. This type of farming is not regarded to be sustainable anymore. It is said that "sustainable agriculture", which is defined as such farming that reduces the dependency on external resources and converts the whole system to a sustainable recycling system, where each resource can be highly utilized, has to be pursued for sound sustainability

(MAFF, 1992). As many Hokkaido dairy farmers are large-scale full-time farmers who have made high initial investments in machinery, facilities, and the like, amortizing their debts requires that they enlarge their herds and keep buying new machinery. But the concomitant of dairy farming that is dependent on purchased concentrate and oriented toward herd expansion and increasing per-head milk yield is frequent sickness among cattle and overwork for farmers, as well as environmental impacts such as pollution of rivers by livestock waste runoff.

In view of this situation, diary farming is being assessed from a compound perspective that considers more than just monetary income (Nekomoto et al [7]). Dairy farmers need specific suggestions and government policy that will result in dairy farming with a balance between herd size and self-supplied feed (especially pasture size), instead of inducing farmers to just expand herds and increase cow milk yield. This paper will explore the problems involved in the livestock management techniques and management of current dairy farming while focusing on the above concerns. The authors will also discuss examples of alternative Hokkaido dairy farming, such as" slow dairy farming" and dairy farming combined with rice growing 1) and give thought to exactly what sustainable agriculture should be like.

2. Trends in Hokkaido Dairy Farming and Problems Faced by Current Dairy Farming Management

2－1　Efforts to Expand Herds and Increase Milk Yield

Hokkaido dairy farming has grown from an average herd of 2. 8 head per farm and milk production of 4, 275kg per cow in 1966 to an average herd of34. 9head per farm and milk production of 7, 403kg per cow in 2000 (Figure 1). Hokkaido's increases in both herd size and milk production are larger than those of all other prefectures, and there is a strong trend toward larger herds and higher per-head yield.

Until the first half of the 1980s the increase in pasture area kept pace with the increase in the number of milk cows, but in the second half of that decade the price of milk and the sale price of cows declined, inducing producers to enlarge their herds and increase yields to maintain their incomes (Matsunaka [5]). At the same time, they starting replacing their own feed with imported concentrate, which had become relatively inexpensive thanks to the strong yen (Okada [8]). It was milk production dependent on purchased concentrate that made herd expansion and yield increases possible. This is

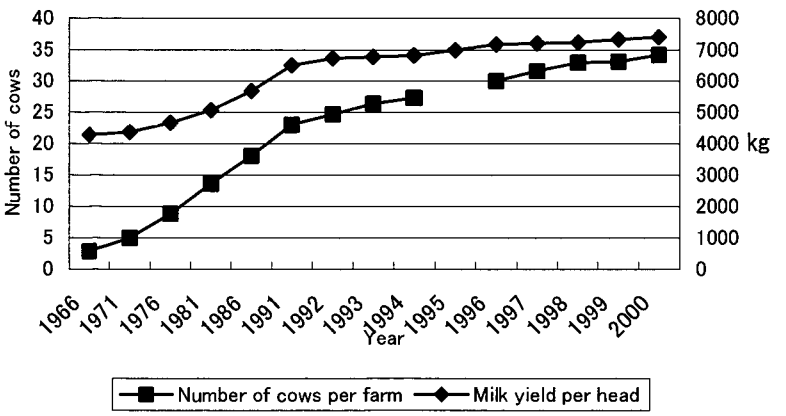

Figure 1 . The number of a farmer's cows and milk yield per head
Data : Statistical Research of Farm Economy 2000, MAFF

also evident from the steady increase in the amount of concentrate provided per milk cow since 1980 to the present (Matsunaka [5]).

The profitability of farming operations according to herd size reveals a trend in which the monetary return per day of family labor and the profit ratio (percent of gross income that is profit) both rise as herd size increases. But while herd expansion and yield increases were intended to boost producers' incomes, they also bring about frequent sickness in cows, impose excessive workloads on families, and cause environmental problems such as polluting rivers with livestock waste that could not be completely used in their own operations.

2－2 Frequent Cow Illnesses and Livestock Welfare

The first problem to be examined is that cows are increasingly falling ill because of herd expansion and yield increases. Probable reasons are changes in the cows' environments because of barn residence and other factors, and diets heavy on concentrate meant to increase milk yield.

A comparison according to herd size of per-head milk yield at 3.5% conversion to the share of feed cost in the total production cost of100kg of raw milk shows that the larger a farmer's herd, the higher the yield per cow and the higher the proportion of feed in total cost (Figure 2). On the other hand, larger herds have fewer average calvings per cow, which tends to raise the percentage of cow depreciation in production cost (Figure 3). This is likely because a diet that is heavy in concentrate increases cow illnesses such as fourth stomach displacement, leading to early retirement and otherwise decreasing the useful life of farm animals as herd size enlarges. In fact most illnesses of milk cows are said to be affected by their feed because the higher the milk/feed ratio (the percentage of feed cost in milk production cost), the higher the rate of loss from death and retirement (Takahashi [10]).

Veterinarians' data from the Nemuro area of Hokkaido, where herd expansion and yield increase have progressed markedly in recent years, show a sharp increase in surgical operations over the last four years, and nearly 90% of

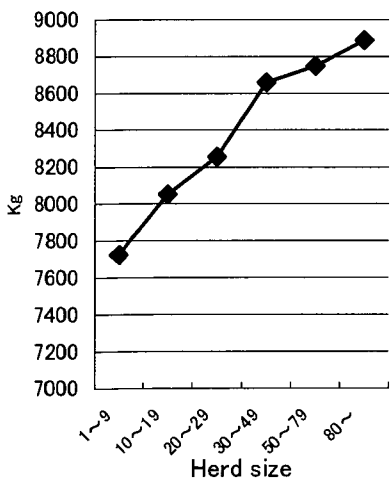

Figure 2. Per-head milk yield at 3.5% conversion

Source: Livestock production cost 2002, Statistics and Information Department, MAFF

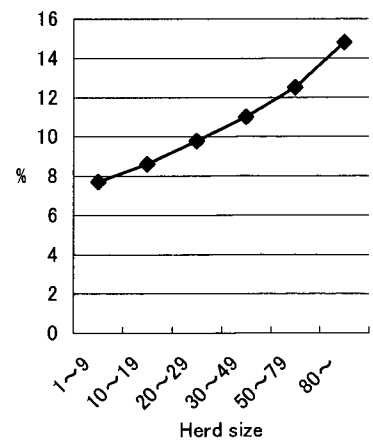

Figure 3. The percentage of cow depreciation in production

Source: Livestock production cost 2002, Statistics and Information Department, MAFF

the disorders were fourth stomach displacement, a condition in which a void forms in the back part of the cow's body cavity, and the fourth stomach positions itself there permanently 2) (Figure 4). Correcting the condition requires a laparotomy. Fourth stomach displacement occurs often after calving, when a cow eats less and the first stomach does not become full. It happens even while lactating when there is a high ratio of concentrate to roughage. Microorganisms in the first stomach cannot work effectively if the balance with roughage is lost by feeding cows much concentrate. Apparently this imposes a burden on the fourth stomach to digest and absorb the feed, making cows susceptible to fourth stomach displacement. Hence, feeding cows much concentrate to increase their production capacity is a cause of illness (Itoh [2]). Frequent illness among milk cows must be dealt with from two perspectives : that of dairy farming profitability, and that of farm animal welfare.

2 — 3 Excessive Workloads Due to Herd Expansion

The third problem is that family workloads are increasing because of heard expansion even though farmers are incorporating machinery, facilities, and other technology into their operations to reduce the labor concomitant with increasing herd size.

Annual working hours per farming family member according to herd size (Figure 5) shows that the number of hours worked increases with herd size. Each person working on dairy farms with herds between 10 and 19 cows works 1, 947 hours, but that rises to 2, 600 hours when herd size is 80 head or more, which is far longer than the annual actual working hours in other industries (1, 825 hours in 2000). It is instructive to see how labor compensation and the agricultural income ratio change in response to an increase in working hours.

The percentages of family labor compensation and income in gross income (Figure 6) indicate that the income ratio and family labor compensation ratio per wet cow rise as herd size increases, but fall after a certain herd size—between 30 and 50 head-has been passed. Thus, although increasing the number of cows increases working hours, there is no corresponding increase in compensation, which means that larger herds do not necessarily make economic sense. This figure suggests that mid—sized

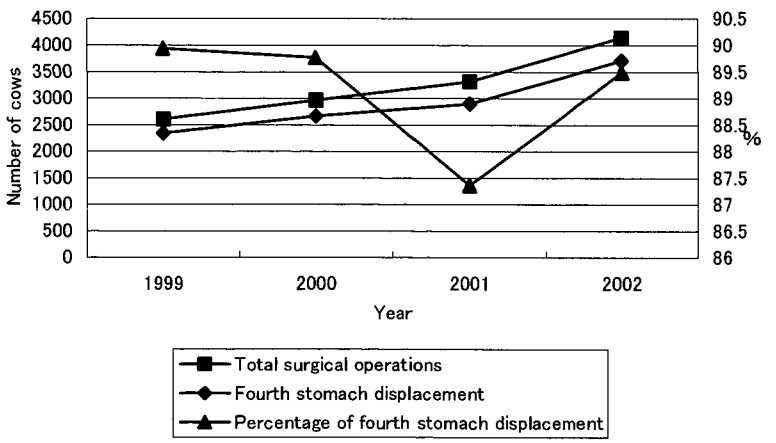

Figure 4 . Number of total surgical operations and fourth stomach displacement in Nemuro area of Hokkaido

Source : Regeional statistics on surgical operation 2002, Nemuro Area Agricultural Benefit Society

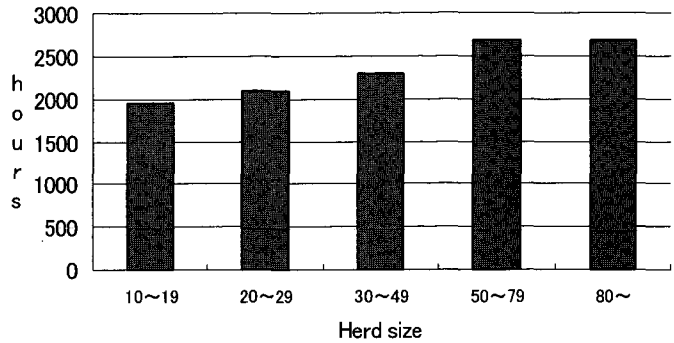

Figure 5. Annual working hours per farming family member
Source: Statistical Research of Farm Economy 2000, MAFF

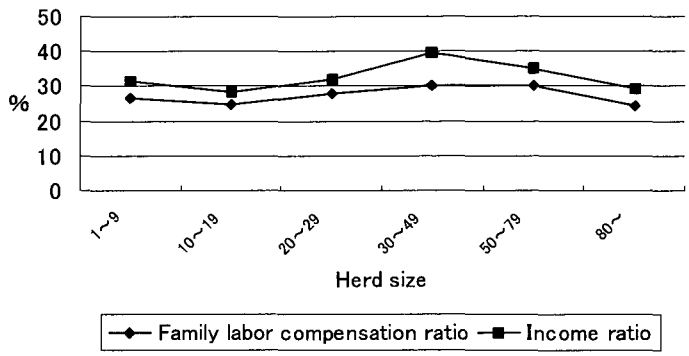

Figure 6. The income ratio and family labor compensation ratio per wet cow
Source: Livestock production cost 2002, Statistics and Information Department, MAFF

herds are most sensible.

The lengthening of working hours in conjunction with herd enlargement has a deleterious effect especially on women's daily lives and working conditions (Araki [1]). For example, a study performed in Hamanaka Town, Hokkaido found that many women in their 40s have considered divorce, ostensibly because this is the age group with the largest dairy operations (Kawai [3]). In response to the question "Have you ever considered divorce?" 55.9% said, "I have considered it," and 14.7% said, "I think about it all the time." Altogether, 69.6% of dairy-farming women in their 40s have considered divorce. The reasons given by the study are that in dairy farming women provide indispensable labor, and that as operations get bigger, the increase in work prevents taking time off, and wives must work about as much as their husbands while also doing housework, which burdens them physically and mentally.

2 — 4 Livestock Waste Management

The third problem is managing livestock waste generated by dairy farming. Operations are now so large that they generate huge amounts of waste which cannot be managed completely by the operations themselves. Because using all the waste as fertilizer is impossible, it becomes an odor source, and when dairy farms are near rivers, waste runoff pollutes them, hinders salmon runs, and causes other problems.

According to data from Hokkaido's Nemuro

Branch Office, one milking cow (multiparous cow) generates about 50kg of waste per day, and an average-sized operation (35cows and 15 heifers) generates 735 tons of feces and urine a year. Applying this waste as is to fields would pollute rivers with runoff caused by rain and snow. In the Nemuro district salmon rivers are polluted by the waste runoff from the many dairy farms along the rivers.

In response to the problems of odor and water pollution, the Law on the Management and Use of Livestock Waste (2000) requires dairy farmers to build composting facilities with roofs and concrete floors within five years. Application to fields and rice paddies in the form of compost or manure slurry is recommended as a way of managing waste to prevent polluting the off-farm environment. Nevertheless, bigger herds generate too much waste, making it impossible to properly manage all of it with existing composting facilities alone. Further, because the heavy use of concentrate gives cow manure high water content, the manure itself it not suitable for composting. For these reasons many farmers must spread the manure on their fields in a nearly unprocessed state, thereby polluting the rivers and surrounding environment from runoff during rainfall and snow melt.

3. Examples of Alternative Dairy Farming

The direct cause of the dairy farming problems described above is herd expansion and high per-head yield dependent on concentrate for the sole purpose of increasing dairy farming income. But some dairy farmers choose not to enlarge herds or increase milk yields, instead mitigating the three problems discussed above by producing as much of their own feed as possible and keeping their animals healthy. Some examples of this alternative dairy farming are discussed below.

3－1　Society for the Future of Bekkai Dairy Farming (Eastern Hokkaido)

Members of the Society for the Future of Bekkai Dairy Farming, organized by dairy farmers in eastern Hokkaido, are small and medium-sized family farms using pastureland. They hold annual study sessions on "slow dairy farming." Session participants have stopped the heavy use of imported concentrate, and mostly use self-produced roughage and grazing, while at the same time maintaining a certain income level. They have departed from modern dairy farming and its large herds, keeping cows in the barn, and dependence on imported feed. Instead, they match herd size to their pastureland, combine summer grazing with winter barn residence, and use mostly self-produced feed. This solves several problems at once by reducing working hours, maintaining cow health, and managing livestock waste, while allowing a more leisurely lifestyle and activities like cheese-making. This is a typical example of alternative dairy farming.

3－1－1　O Farm

O Farm in Bekkai Town is a member of the Society for the Future of Bekkai Dairy Farming. In the autumn of 1991 they switched to a system using mainly roughage and grazing, and gradually diminished their herd, including the number of multiparous cows. This conversion led to the gradual decrease of total farming income, and gross income ratio (the percentage of farming income in gross farming profit) fell in 1991 when the switch was made, but subsequently tended to rise and is now over 50% (Figure 7). This income ratio is higher than that under usual management practices, which is because the expenditure decrease outweighs the income decrease (Figure 8). A breakdown of decreased expenditures shows a big factor to be that outlays for feed, the largest expenditure, dropped to less than half after the switch, and improved

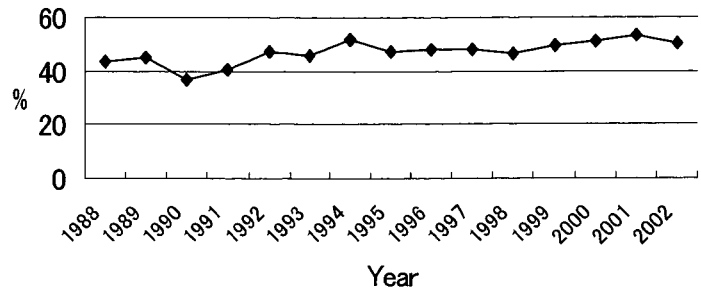

Figure 7. Gross income ratio
Source : Livestock production cost 2002, Statistics and Information Department, MAFF

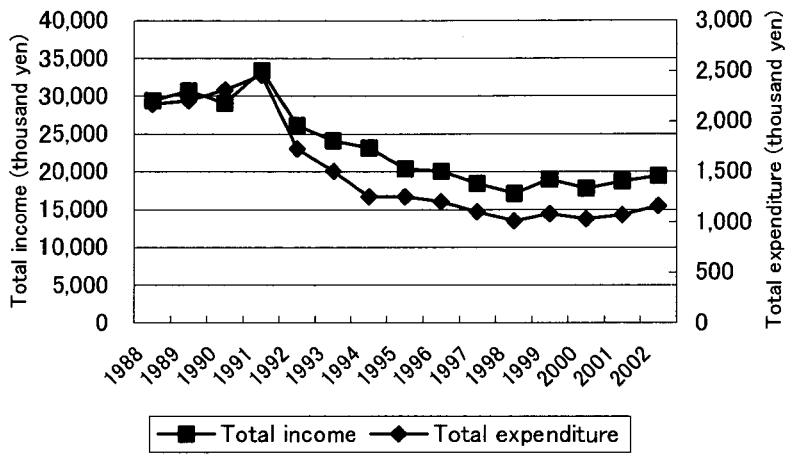

Figure 8. Change in total expenditure and income of O farm
Source : Study session for present and future of dairy farming, Society for the Future of Bekkai Dairy Farming

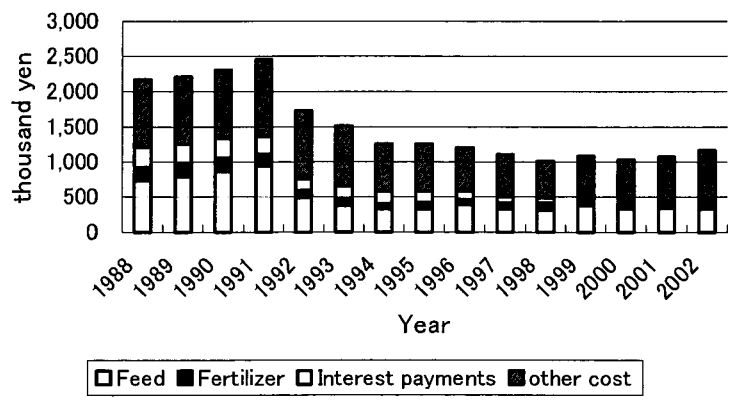

Figure 9. A breakdown of decreased expenditures
Source : Study session for present and future of dairy farming, Society for the Future of Bekkai Dairy Farming

management also quickly reduced interest payments (Figure 9).

Feed costs were lowered by curbing the use of purchased feed and switching to a herd management technique that depends mainly on grazing. Because this management technique provides the animals with much grass and other roughage, the cattle are healthier and barn cleaning is easier. Heifers are fed mainly hay and plenty of other roughage, and compound feed is used to compensate for lacking nutrients, which results in healthy animals which have well-developed first stomachs are adapted to grazing. Their manure has a high fiber content and low moisture content, making it suitable for composting.

Reducing concentrate in the diet lowers milk yield, and decreases milk price because it is based on milk components. Although milk income falls, production outlays also decline because herd size is adjusted to pasture size, external fixed capital expenditures such as machinery and facilities are reduced, and the cost of purchased feed lessens. Further, healthy cows mean lower cow depreciation cost, reduced veterinarian fees, and other decreased expenses. Overall, running dairy operations this way presents more advantages than disadvantages.

Such "slow dairy farming" research groups are trying to depart from the large-heard, high-yield model through a system of new herd management techniques. They hold get-togethers to exchange techniques and information for this purpose, and have the participation of not only dairy farmers, but also veterinarians and researchers from agricultural experimental stations.

Table 1. Criteria for organic milk production in Setana

	Production Criteria
Feed	1 : 60% of net weight of the feed must be domestic products, and organic feed must account for more than 80% of domestic feed. 2 : The feed must be Non-GMO
Health management	1 : The use of antibiotic must be avoided as much as possible. The name of antibiotic, if any is administered, must be recorded. 2 : Feeder for organic cows must be kept separate from that of Non-organic cows.
Breeding	1 : Artificial insemination is permitted. 2 : Genetically modified cows and the cows that are transplanted or extracted fertilized eggs are not allowed.
Animal welfare	1 : The cows house must be kept clean by regular cleaning. 2 : Live stock waste must be disposed properly. 3 : Access to the outdoors, ample waters and bedstraws must be satisfied so that social habit of cows 4 : Ample room for each cow.
Product quality	1 : The number of body cell per milliliter must be under 300,000. 2 : The number of bacterium per a milliliter must be under 10,000. 3 : Organic cows must be milked before Non-organic cows. The organic milk must be kept in special bulk cooler so that it does not mixed with conventional milk.
Record	1 : Buying and selling, transportation, feed, medicine of each cow must be recorded in the way prescribed by the city.
Transition	1 : The transition term from Non-GMO to GMO is one month after the method of breeding along this standard is applied.
Conversion	1 : The conversion is accepted after11month from the transition term.

Source : Hokkaido Setana city publicity "Setana", 2003

3－2 Organic Milk Production by Combining Rice Production and Dairy Farming (Setana Town)

Setana Town, which faces the Sea of Japan in southern Hokkaido, created its own standards for organic milk production in2002and is working to develop dairy farming that meets them. These standards were established in response to livestock product safety requirements, which heightened owing to the BSE (bovine spongiform encephalopathy) issue, and their main features are no use of genetically modified feed, self－produced feed that uses no pesticides or chemical fertilizers, and the use of compound feed containing no genetically modified products. The standards also require consideration for livestock welfare, such as by grazing cattle and caring for their health (Table 1). Some of the organic milk produced is shipped to the town-operated Dairy Product Processing Center to be processed into ice cream and butter and sold. Some milk is used in local school lunches. When organic raw milk is sold to the Center the town pays producers a subsidy of 20yen per kg over the Hokuren pool milk price. One hopes that Setana's organic milk production standards, which were created for the purposes of encouraging sustainable dairy farming and giving added value to local resources, will serve as clear standards that can be shared by both producers and consumers, and in that capacity build trust between the two groups.

3－2－1 T Farm

Three farms in Setana Town currently practice organic dairy farming. One of them, T Farm, produces both rice and milk. Since October 2002 it has been producing and shipping 2 tons of organic raw milk monthly (24 tons annually). In 2002 the farm also received certification for the duck rice (rice cultivated by keeping ducks in the paddies) it had been growing previous to this. Cattle manure is composted in a facility on the farm, and all of it is applied to rice paddies and pastureland to maintain fertility.

Table 2 shows an overview of T Farm. Husband and wife do milking and chores from 5：30 to 7：30 in the morning and 6：30 to about 8：00 in the evening. In the summer the husband tends the rice paddies and the wife grows vegetables in hothouses. Working hours are longer than the usual farm growing rice alone, but when possible nearby farmers work together.

A barn cleaner piles the manure in a roofed composting facility and turns it until fully composted. The product is spread on hay fields in the spring and fall. Herd size is adjusted to hay field area, and when there is not enough grass T Farm trims its herd by selling heifers instead of buying feed from outside.

Organic rice is used in local school lunches, and is also sold as rice to make sake (in Setana Town a sake-brewing company is commissioned to make the product, which is sold under the brand name "Ginko Monogatari" after Ginko Ogino, Japan's first woman physician, who

Table 2. An overview of T farm

Land area	Rice paddies 10.2ha (2.2ha organic, 7ha conventionally tilled, 1ha fallow), Pastureland 6 ha, Hay field 8 ha
Livestock herd	Multiparous cows 15, Heifers 12
Labor	Husband and wife
Milk production	Raw milk production 80tons. Average 6,500kg per lactating cow. Average calvings per cow 4.5
Feed	Roughage is hay and roll silage, concentrate is non－GMO compound feed, beet pulp, and rolled barley, 5 to 6 kg daily for each lactating cow. Purchase cost is 1.8million yen a year.
Grazing	Summer (late July to late November), daytime only.

worked in Setana). The rest of the organic rice is milled and sold to consumers through the Setana Organic Club, which was started by a group of five producers including T Farm. Through direct sales T Farm gets a net income of 27,000 yen per bag of brown rice (ordinary rice goes for 14,000 yen). Organic raw milk is sold through the agricultural cooperative, while some is taken to the town Processing Center as noted above. The Center pays an extra 20 yen per kg (usually it is about 70 yen). T Farm's annual gross income from both rice and milk is about 2 million yen (about half of that is from rice), which is above the local average.

T Farm's combined rice/dairy farming is a form of agriculture that the farmers themselves developed to secure farm income under the topographical conditions of southern Hokkaido, which has few level areas and many slopes because of the mountains. The wave of dairy farming modernization and specialization has eliminated most rice/dairy farming operations in southern Hokkaido, leaving only four in Setana Town, including T Farm. But this farm's example demonstrates that even with few cows (T Farm has 15), not only does combining dairy and rice farming generate a livable income, but also by using all the compost that is a byproduct of dairy farming and by incorporating duck rice cultivation, they are successfully producing and selling high-added-value organic rice. Additionally, the processing of some organic milk and rice into dairy products, sake, and other products gives the town an "organic" image, and heightens awareness in the community of consuming locally produced food locally.

This Setana Town initiative based primarily on organic milk and the rice/dairy combination is in the spotlight as an alternative to modernized agriculture especially from the perspective of livestock waste management, farm animal welfare, and raising public awareness.

4. Summary and Conclusion: Policy Implications

This analysis has elucidated the problems in modern dairy farming with its orientation toward herd expansion and high per-cow yield. These problems are, first, the high incidence of livestock illness and the inattention to animal welfare; second, overwork by dairy farmers; and third, environmental impacts such as river pollution by livestock waste. Our analysis also described two examples of alternatives to modern dairy farming by farmers themselves: the dairy farmers using mainly grazing, who come together at the" slow dairy farming" study sessions in eastern Hokkaido, and the combined rice/dairy farming of Setana Town in southern Hokkaido. These methods' significance as recycling−based farming methods was also explored 3). This analysis yielded the following four policy implications for achieving sustainable dairy farming.

First, the precondition for sustainable dairy farming is the greatest possible self-sufficiency in feed, which in turn requires efforts for the reevaluation and use of local feed resources. Further, replacing purchased feed with self−produced feed helps reduce the major cost of livestock production. Second, grazing cattle and otherwise keeping them as healthy as possible maintains their productive capacity, which reduces depreciation cost and otherwise contributes to the effective use of livestock capital. This is also desirable for animal welfare. Third, because it is small family farming operations that support sustainable dairy farming, it is necessary to develop and disseminate technologies suited to their operations, and especially to identify rural technologies. Fourth, sustainable dairy farming initiatives must attain social acceptance by supplying safe food. For that purpose it is crucial to go beyond a price system based solely on milk components, and to create a system and distribution arrangement that al-

low producers and consumers to share information, including a reassessment of the value of foods produced by organic and sustainable methods.

1) "Slow dairy farming" intends to match herd size to their pastureland, combine summer grazing with winter barn residence, and use mostly self-produced feed. "Dairy farming combined with rice farming" adjusts herd size to hay field area. Since both farming aim for more sustainable agriculture, the authors take them as the examples of sustainable agriculture.

2) The referee pointed out that it is necessary to put the percentage of total surgical operation in total cows in Figure4. However, the authors did not acquire the appropriate data on the total number of the cows in Bekkai area as a whole.

3) As the referee reader pointed out, O Farm and T Farm have disadvantages to be considered: their low level of farming income and the problem of overworking due to the convergence to more sustainable agriculture. In our research, both O Farm and T Farm took no particular measure against overworking. In the answer to our question, they took it for granted that they work longer to make a more sustainable recycling system than before the conversion. Further examination is required in order to find the appropriate way to overcome these problems.

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