DAIRY SYSTEMS AND SUSTAINABILITY

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ABSTRACT: We analyzed how three different dairy management systems –continuous grazing, confinement and management intensive grazing- compare across nine sustainability indicators set by the Dairy Stewardship Alliance. A self-assessment survey comprising animal husbandry, biodiversity, energy, community health, farm financials, nutrient, pest, water and soil management was assessed twice across the same farmers. Preliminary results indicated that pasture-based farms, particularly those implementing management intensive grazing, had significantly fewer cows, less acreage and produced less milk than confinement. However they scored higher sustainability especially on farm financials and soil management indicating higher chances of survival of medium and small pasture based farms. Also, most sustainability indicators improved on the second assessment where management intensive grazing and traditional grazing farms scored above confinement revealing that education and access to information were essential to improve management practices and sustainability.

Keywords: Dairy management, sustainability, grazing, confinement,

Introduction

Livestock are major drivers of environmental change in particular, affecting the sustainability of farming livelihoods, communities, and ultimately water and soil resources (MEA 2005; Steinfeld et al. 2006; Koneswaran & Nieremberg 2008; Pelletier & Tyedmers 2010). Globally, around 38% of earth's land area is under some agricultural use (FAO 2004) and within this context, livestock represents the single largest anthropogenic land use in the world, occupying between 25 to 45% (Asner et al. 2004; Herrero et al. 2009). According to Steinfeld et al. (2006) livestock systems represent only 1.5% of the world's economy and provide 8% of all calories. Yet, they contribute 18% of total anthropogenic greenhouse gas, take up 35% of all arable land for feed, contribute to 58% of the anthropogenic biomass appropriation, consume 8% of the planet's fresh water, and occupy 26% for pasture (Steinfeld et al. 2006).

The dairy sector is a major provider of livelihoods supporting rural communities worldwide. Hence, achieving a sustainable balance between sound dairy practices, sustainable livelihoods and environmental protection has paramount relevance. Conventional dairy (and beef) systems may degrade ecosystems compromising its structure and functions. For example, continuous grazing, widely practiced worldwide may produce overgrazing, a major cause of environmental impact because it can lead to above and below ground biodiversity and fertility loss, erosion, lower infiltration rates, higher nutrient runoff (Suttie, et al. 2005) and meager revenues. Similarly, confinement operations are largely adopted in industrialized countries and require animals to be housed and fed subsidized high input feed (Hinrichs & Welsh 2003). The result of these practices affect soil, habitat, biodiversity and water quality, causing pollution and reducing environmental health.

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The United States dairy industry has changed dramatically in the last fifty years, shifting from an extensive system of small and medium-sized farms owned by family farmers, to a system of large, intensive operations where cattle are housed and fed in confined structures. There has been a consequent sharp decline in the number of dairy farms. These changes have brought about significant yield improvements, but have also created new challenges in dairy management with environmental performance, public health, farm finance, rural community stability, and the health and well-being of livestock (PewCommision 2008).

The latest U.S. dairy trend shows that farms are getting larger, with more cows and each cow is producing more milk. The number of US dairy farms has decreased by 38.9% while the number of milking cows declined 12.8% from 1997 to 2007. The production per cow has increased steadily since 1970 to 2006. Also, between 2000 to 2006, farms with less than 100 cows decreased by 29%, while farms with more than 499 cows rose by 44 % (USDA-NASS 2007). Additionally, in Northeastern United States (including New York, Vermont, Pennsylvania, Maryland, New Hampshire, Massachusetts, Rhode Island, Connecticut, and Maine), between 1960 and 2006, the total number of dairy farms has decreased by 83%. The number of milking cows in the region has increased by 49%. Yet, the average milk production per cow has more than doubled over this period (USDA, NASS, 2007). The present tendency is consolidating fewer but larger farms (Figure 1) (Mac Donald et al., 2007) which is also confirmed by Hinrichs & Welsh (2003). Moreover, although the average herd size in the U.S. dairy is only 80 cows, industrial dairy herd size ranges between 500 and over 1,000 cows (Hinrichs & Welsh 2003).

Dairy industry largely dominates commodity production in Vermont. There are over 64 thousand milking cows in 864 dairy farms with up to 99 cows, while there are over 171 thousand milking cows in 370 dairy farms with a herd size ranging from 100-2,500 (USDA-NASS 2007). The census data also indicates that the median farm size in Vermont has systematically decreased 10% from the last census in 2002 from 100 to 90 acres, being Essex, Orleans and Addison the counties that had the biggest acreage decrease (-41.9%, 24.3% and 20% respectively). Only Grand Island and Rutland counties increased farm acreage (12.4% and 9.9% respectively) (USDA-NASS 2007).

To restore the benefits of ecosystems, produce food and improve rural livelihoods in the same land, farmers' need a more benign and agroecological system. Agroecology is an interdisciplinary approach to agriculture which performs under ecological principles in managed agroecosystems (Méndez 2010). Agroecology contemplates the multifunctionality of agroecosystems (Gliessman 2010) and has often been implemented to address the needs of poor farmers in degraded lands. Voisin management intensive grazing is an agroecological system that relies on well-managed pastures and can potentially restore the benefits provided by ecosystems, increasing food production and quality and enhancing rural livelihoods. It consists of a form of management that rationally rotates animals though a subdivided pasture where animals, forage and soil mutually benefit.

The goal of this study was to evaluate the sustainability of dairy production systems in promoting and enhancing environmental, economic and social conditions. The overall objective was to assess which dairy management system achieved higher production and sustainability scores and to compare a subset of farms that completed two assessments to determine whether education and access to information can improve farmers practices;

Methodology

Studied farms comprised over 12,000 acres and 13,000 cows. They were located in the counties of Franklin, Lamoille, Orleans, Essex, Addison, Rutland, Chittenden, Windsor, and Bennington Vermont. Farms were randomly selected and mailed a self-assessment questionnaire which included nine sustainability indicators: 1) animal husbandry; 2) biodiversity; 3) community health; 4) energy; 5) farm financials; 6) nutrient management; 7) pest management; 8) soil health; and 9) water management. Some modules were related to other modules directly or indirectly. The goal was to provide farmers with information about current practices and compare them economically, socially and environmentally to best management practices. Farmers could then identify areas to improve and transition to desirable farming practices. Following an educational information, the same questionnaire was mailed again two years later to assess whether farms had improved their practices. Thirty nine farmers returned complete questionnaires in the first assessment and only 29 in the second. Upon receiving the surveys, we assessed differences between first and second assessment and dairy management methods using parametric and non-parametric statistical methods.

Results and Discussion (Preliminary)

The comparison between the first and second assessment revealed an improvement in all sustainability indicators with six out of nine indicators, animal husbandry, biodiversity, community health, nutrient, soil and water management, being significantly different, $p \leq 0.05$. This suggests that access to information and education were an essential component of the project. The self-explanatory questionnaire had practical tips and access to external educational resources at the end of each module. Farmers also had access to educational training sessions which made possible the improvements.

Dairy size has been found to be directly related to the dairy system management and quality of life of surrounding communities (Hinrichs & Welsh 2003). Many researchers found an inverse relation between dairy size operation, the quality of life of the community and the profitability of dairy farms after comparing small and medium size farms who practice intensive grazing management with conventional dairy (Murphy 1998; Hinrichs & Welsh 2003).

In the first assessment, the comparison between the three management systems showed that confinement farms had more cows and milk production $p< 0.019$ and $p<0.003$ respectively. MIG had the least amount of animals and the lowest production. Confinement also used more owned and cropped land yet, MIG scored higher than confinement and continuous grazing in soil management $p<0.031$. While confinement operations confirm its yield supremacy, it also exposes weakness in the modules: energy, community health, biodiversity and financial.

In particular, when we assessed the financial module, across the three management methods between the two assessments confinement and continuous grazing scores were in deficit while MIG's scores were positive. Moreover, despite MIG was significantly different for some of the modules of sustainability, its scores were systematically higher than continuous grazing and confinement. In particular, MIG financial scores differed from confinement, thus confirming that MIG had economic advantages over confinement. Other studies have shown higher profit margins per cow and per unit of milk sold for pasture-based farms under MIG, compared to confinement (Winsten 1999; Benson 2008; Winsten et al. 2010). This can represent a great disadvantage to confinement because, if a management method is not profitable, it cannot be sustainable and will not be used by farmers.

Moreover, MIG costs are lower, resulting in higher profitability compared to confinement and continuous grazing due to: (a) lower inputs (fertilizer, pesticides, energy, machinery) because animals harvest most of their own high-quality forage and spread their own manure (Pinheiro Machado 2004); (b) positive energy balance because its main input comes from the sun and forage plants are managed for maximum photosynthesis (Pinheiro Machado, 2004) and, (c) protection and enhancement of the environment (Melado 2007). Smaller pasture-based farms under MIG have shown greater quality of life, larger net farm income, closer relationship with the cows, the land and the community and higher chances of survival of medium and small farms (Ostrom & Jackson-Smith 2000; Gerrish 2004; Cooner et al. 2009).

On the other hand, confinement and continuous grazing farms have much higher costs mainly because of the greater need for supplemental feed purchased off farm. Continuous grazing farms incur in much of these same costs because they operate almost like confinement farms, in that they don't rely on pasture as an important source of forage, but really only use it as exercise areas (Murphy 1998). Most continuous grazing farms feed the same total mixed ration (TMR) year-round, regardless of pasture availability (Soder & Rotz 2003). Cows under continuous grazing are probably healthier than their confinement counterparts because they do get out on pasture. High confinement culling rates (50%) due to unhealthy conditions and hormone use exceeds eight times the rate of culling for mastitis in comparison to pasture based methods (Washburn et al. 2002) This, ultimately forces confinement farms to replace all cows every 2 years at a cost of $2000 per heifer.

Conclusion

This research aimed to study and promote sustainable dairy practices that consider environment and equity of rural people in the United States.

By confirming most of the research assumptions and describing an alternative dairy system that scored significantly higher sustainably in five out of nine indicators, our findings intend to establish a future path for reconciliation between conservation, dairy production and rural livelihoods. Pastures managed under MIG yielded greater animal production per acre, imposed heavy grazing without permanently damaging plants, provided food more sustainably, improved nutrient cycling, enhanced soil formation, controlled erosion, and reduced greenhouse gas emissions through carbon sequestration and storage, in comparison to continuous grazing. Confinement had more animals and produced more milk, however it scored lower in most indicators, particularly in the financial indicator.

These preliminary findings could help policymakers to incentivize agroecological practices that enhance the environment, promote conservation and better dairy farming practices.

Furthermore, by understanding the farmers' and environmental constrains, it seems economically wise to reduce or shift farm subsidies that support conventional agriculture towards farmers who adopt agroecological practices.

In this sense, education and access to information played a very important role by informing farmers about agroecological practices. However, perhaps they are not enough to achieve conservation of ecosystems, higher production and enhanced rural livelihoods. Sound financing mechanisms and extension services seem to be essential to achieve this especially with smaller farms.

References

1. Asner, G. P., A. J. Elmore, L. P. Olander, R. E. Martin, and A. T. Harris. 2004. Grazing Systems, Ecosystem Responses, and Global Change. Annual Review of Environment and Resources 29:261-299.
2. Benson, G. A. 2008. Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. Journal of International Farm Management 04.
3. Chambers, R. 1989. Farmer first: a practical paradigm for the third agriculture. Pages 237-244 in M. A. Altieri, and S. B. Hecht, editors. Agroecology and small farm development. CRC Press, Boca Raton, Fla., USA.
4. Chambers, R. 1995. Poverty and livelihoods : whose reality counts? Institute of Development Studies at the University of Sussex, Brighton, Eng.
5. Chambers, R., and G. Conway. 1991. Sustainable rural livelihoods: practical concepts for the 21st Century. IDS-University of Sussex, Brighton.
6. Cooner, D., D. Rozeboom, and V. Campbell-Arvai. 2009. Literature Review: A Comparison of Dairy Production Systems. Department of CARRS, Michigan State University.
7. Costanza, R., M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, M. Van den Belt, R. D'Arge, R. De Groot, and S. Farber. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.
8. Daily, G. C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, and G. M. Woodwell. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Ecological Society of America 2:18 p.
9. Dale, V., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64:286-296.
10. Daly, H., and J. Farley 2010. Ecological Economics: Principles and Applications: 2nd edition. Island Press, Washington, DC.
11. DFID. 2004. Agricultural Sustainability. Page 23 in D. f. I. Development, editor. University of Essex, UK.
12. FAO. 2004. Statistics of the FAOStat. Food and Agriculture Organization of the United Nations, On line: www.faostat.fao.org.
13. Gerrish, J. 2004. Benefits of Management-intensive Grazing. University of Missouri-Forage Systems Research Center, Saint Louis.
14. Gliessman, S. 2010. Landscape Multifunctionality and Agriculture. Journal of Sustainable Agriculture 34:465-465.
15. Herrero, M., P. K. Thornton, P. Gerber, and R. S. Reid. 2009. Livestock, livelihoods and the environment: understanding the trade-offs. Current Opinion in Environmental Sustainability 1:111-120.
16. Hinrichs, C. C., and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.
17. IFAD. 2004. Livestock services and the poor. Page 152. International Fund for Agricultural Development.
18. Koneswaran, G., and D. Nieremberg. 2008. Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. Environmental Health Perspectives 116:578-582.
19. Kotschi, J. 2007. Agricultural biodiversity is essential for adapting to climate change. Gaia-Ecological Perspectives for Science and Society 16:98-101.
20. Lai, R. 2007. Managing Soils for Food Security and Climate Change. Journal of Crop Improvement 19:49-71.
21. LID. 1999. Livestock in Development: Livestock in Poverty-Focused Development.95.
22. Melado, J. 2007. Pastagem ecológica e serviços ambientais da pecuaria sustentavel. Revista Brasileira de Agroecologia 2.
23. MEA 2005. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.
24. Méndez, V. E. 2010. Agroecology. Page in press in B. Warf, editor. Encyclopedia of Geography. Sage Publications, Thousand Oaks, CA.
25. Murphy, W. M. 1998b. Greener pastures on your side of the fence: better farming with Voisin

management intensive grazing. Arriba Pub, Colchester, VT.
26. Ostrom, M. R., and D. B. Jackson-Smith. 2000. The Use and Performance of Management Intensive Rotational Grazing Among Wisconsin Dairy Farms in the 1990s. Program on Agricultural Technology Studies research report No. 8. University of Wisconsin, Madison.
27. Pelletier, N., and P. Tyedmers. 2010. Forecasting potential global environmental costs of livestock production 2000–2050. Proceedings of the National Academy of Sciences 107:18371-18374.
28. PewCommision. 2008. Pew Commision on Industrial Farm Animal Production. Putting Meat on the Table: Industrial Farm Animal Production in America. Pew Charitable Trust and the Johns Hopkins Bloomberg School of Public Health
29. Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55:573-582.
30. Pinheiro Machado, L. C. 2004. Pastoreo Racional Voisin: Tecnologia agropecuaria para el tercer milenio. Hemisferio Sur, Buenos Aires.
31. Reid, R. S., K. A. Galvin, and R. S. Kruska. 2008. Global Significance of Extensive Grazing Lands and Pastoral Societies: An Introduction. Pages 1-24 in K. A. Galvin, R. S. Reid, R. H. B. Jr, and N. T. Hobbs, editors. Fragmentation in Semi-Arid and Arid Landscapes. Springer Netherlands.
32. Rudel, T. K. 1998. Is there a forest transition? Deforestation, reforestation, and development. Rural Sociology 63:533-552.
33. Sanderson, E. A., M. Jaiteh, M. A. Levi, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The Human Footprint and the last of the Wild. Bioscience 52:891-904.
34. Scherr, S., and S. Yadav. 1996. Land degradation in the developing world: implications for food, agriculture and the environment to 2020, a synthesis of recommendations from an international workshop. Food, Agriculture, and the Environment Discussion Paper No. 14. , Washington, DC.
35. Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS), Brighton, UK.
36. Spiertz, J. H. J. 2010. Nitrogen, sustainable agriculture and food security. A review. Agronomy for Sustainable Development 30:43-55.
37. Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. Livestock Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations:408 pg.
38. Suttie, J., S. Reynolds, C. Batello, Food, and A. O. o. t. U. Nations 2005. Grasslands of the world. Food and Agricultural Organization of the United Nations.
39. Soder, K. J., and C. A. Rotz. 2003. Economic and Environmental Impact of Utilizing a Total Mixed Ration in Pennsylvania Grazing Dairy Herds. The Professional Animal Scientist 19:304-311.
40. Szott, L., M. Ibrahim, and J. Beer. 2000. The Hamburger Connection Hangover. Cattle pasture land degradation and alternative land use in Central América in D. CATIE, GTZ, editor.
41. USDA-NASS. 2007. 2007 Census Publications.
42. Vitousek, P. M., J. D. Aber, R. W. Howarth, G. E. Likens, P. A. Matson, D. W. Schindler, W. H. Schlesinger, and D. G. Tilman. 1997. Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications 7:737-750.
43. Winsten, J. 1999. The profitability of management-intensive grazing for northeastern dairy farms. American Journal of Agricultural Economics 81:1296-1296.
44. Winsten, J. R., C. D. Kerchner, A. Richardson, A. Lichau, and J. M. Hyman. 2010. Trends in the Northeast dairy industry: Large-scale modern confinement feeding and management-intensive grazing. Journal of Dairy Science 93:1759-1769.
45. Washburn, S. P., S. L. White, J. T. Green, and G. A. Benson. 2002. Reproduction, mastitis, and body condition of seasonally calved Holstein and Jersey cows in confinement or pasture systems. Journal of Dairy Science 85:105-111.
46. Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.