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IMPACT OF TILE DRAINAGE ON OPTIMAL ENTERPRISE COMBINATIONS AND PROFITABILITY OF NORTHERN NEW YORK DAIRY FARMS

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INTRODUCTION

Poor drainage is a generally recognized limiting factor for agricultural development in Northern New York (Lucey, 1977a). It limits the productive capacity of the land, thereby reducing the income-generating ability of the dairy farms which dominate the local agriculture. Tile, or subsurface drainage, is often recommended as a way to alleviate the problem. This publication reports the results of an economic analysis of tiling on Northern New York dairy farms.

Depending on the resources available and the management strategies followed, many adjustments in the organization and operation of the farm should follow the installation of the tile. The farm manager can make changes in input use, scheduling of operations, crop enterprises, feeding system and herd size.

Tiling is an investment which catalyzes other changes in the farming system. Economic analysis of this investment must take into account these ramifications. Since the dairy farming system has strong links between the crop and livestock enterprises, the unit of study is the farm. The costs and benefits of the change cannot be completely evaluated except by examining the effects on all farm enterprises and the linkages between the enterprises.

Some Background on Northern New York Agriculture

Although Northern New York is generally considered to consist of Jefferson, St. Lawrence, Lewis, Essex, Franklin and Clinton Counties, for the purposes of this study, the emphasis is on northern Jefferson, St. Lawrence, Franklin and Clinton Counties (Figure 1). This area is by no means completely homogeneous, although there are common characteristics. Much of the region is a plain of heavy soils, the rest is mostly Adirondack Mountains. The sparse population is traditionally agricultural. The largest uses of land are forest and dairy farming. As a region, it is one of the major milk producers in the state; St. Lawrence and Jefferson Counties rank first and second in the state in cow numbers (U. S. Dept. of Commerce).

Within the region, dairying outstrips the other important agricultural industries: apple, potato, and birdsfoot-trefoil seed production (Lucey, 1977b). The economic importance of dairying is indicated by its role in the input-output model developed for Clinton County (Hizer and Fisher). For dairy farming, the type II income and employment multipliers ranked third and fifth among all industries in the county. The milk-processing industry ranked first in both multipliers. No other local, production-oriented sector ranked higher. Dairy farming has both regional and statewide importance. With its role shown in the input-output model, its growth could be a powerful stimulus to total economic growth of the region. Unemployment is a chronic problem, the the regional rate being consistently higher than the statewide rate (New York State Dept. of Labor). Growth in the milk-processing sector, closely linked to the production sector, would spur

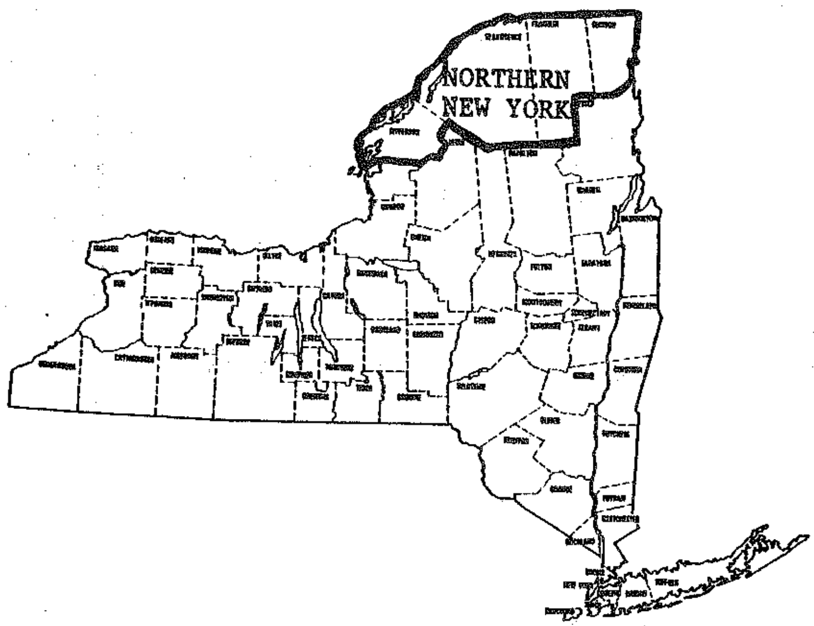


Figure 1. Northern New York.

employment at a higher rate than would any other sector (Hizer and Fisher, p. 37). Therefore, seeking means to promote the development of dairy farming is relevant and can contribute to the overall economic well-being of the region.

The potential for growth lies in the quality of resources available and in the factors currently limiting expansion. Poor drainage has been a major factor in determining the character and productivity of Northern New York agriculture. Tiling is believed to have the potential of eliminating, or at least alleviating, this constraint.

Much of Northern New York is a low-lying nearly level to gently sloping alluvial plain of the St. Lawrence River Valley. Many of the major soils, such as Kingsbury, Rhinebeck, Niagara, Pittsfield and Hogansburg have surface horizons of low permeability. Other soils are underlain by a fragipan, as Naumberg, Westbury, Brayton and Swanton. Some 45 percent or 594,000 acres of the cropland is classified as poorly drained (Lucey, 1977b).

Many of the problems of Northern New York agriculture which are blamed on a cold wet climate are actually consequences of poor drainage (Lucey, 1977b). By delaying tillage in the spring and hampering harvest in the fall, poor drainage shortens the growing season. Corn silage planting and harvesting operations are frequently hampered by excessive soil moisture.

There is also the possibility that the corn may never be harvested at all, which happened on many farms during the 1976 and 1977 seasons. Planting later and harvesting earlier may avoid the wet seasons but will further reduce yields. The result has been a favoring of less risky grass hay forages, lower expected yields and higher costs than in other regions of the State.

Hay crops, which have a different harvest schedule and need not be replanted annually, are better adapted to poor drainage. The hay crops might be improved by the inclusion of alfalfa. However, alfalfa is very sensitive to poor drainage, which tends to exacerbate winterkill. Birdsfoot-trefoil is a less attractive alternative but, it too, is more sensitive to poor drainage than grass. Though few farmers go to the extreme of depending totally on pasture and grass hay, many are near that end of the spectrum. Poor drainage, although a single characteristic of the soil, has multiple effects on the farming system.

The principal potential of improved drainage lies in allowing the farmer to achieve greater quantity of nutrients from crop production. Expected yields of existing varieties of crops are raised, and/or higher yielding crops, such as corn silage or legume-based hays, can be introduced. Cropping operations can be completed in a more timely manner, and risk of crop or harvest failure is reduced.

The potential for improving soil productivity in Northern New York through modification of drainage patterns was recognized in the early 60's by Zwerman, who advocated the use of land-smoothing where water conductivity was low. More recently, tile drainage has been promoted as more effective in removing excess water and deepening the root zone. The Agricultural Water Management Program at Cornell University is analyzing the impact of tiling and the deterents to its adoption.

Improved Drainage as a Technological Change

Technological change is a source of increased productivity and a generally accepted contributor to agricultural development, and as such, has been the subject of a variety of research efforts. These studies have focused more often on the "macro" level, looking at impacts in terms of national economic growth, employment and distribution of benefits.

In the agricultural economics literature, the studies of technological change fall into two broad categories: macro and micro. The former are more numerous. Researchers and sponsors have been more concerned with the national or sector-level effects, than the firm-level effects. Macro studies have focused on the costs and benefits of generating and dispersing new technologies, the repercussions in the whole economy from a change in one part and the factor shares of labor and capital. Over the past several years, concern with income distribution has grown.

Two micro studies relevant to this project are Good *et al.* and Ashraf and Christensen. Good *et al.* examined the economic impacts of various manure disposal methods proposed for pollution control. They constructed synthetic dairy farms using linear programming and then determined the costs of different disposal systems using partial budgeting. The preferred system depended on the farm size and existing barn and manure-handling facilities.

Ashraf and Christensen used linear programming to look at optimal organization of the farm--both livestock and crop enterprises--with different disposal practices. Labor availability was a key in determining crop selection; spring and fall spreading coincide with corn planting and harvesting. This research included a noteworthy attempt to show the physical linkage between the crop and livestock enterprises by incorporating the fertilizing effect of the manure in the linear programming model. This illustrates how linear programming can be used to depict the physical linkages between components of a production system.

In linear programming, optimization is performed within the limits of the resources available, taking into account the resource requirements of the activities. The types and amounts of resources available and used by the activities may be revised to reflect changes in resource quality or introductions of new technologies. In this study, tiling improves the drainage of the land resource. Two resource complements, identical except for the changes resulting from tiling, were specified to represent the production constraints before and after tiling. Comparison of the linear programming solutions show the optimal reallocation of the farm's resources after the change in drainage.

The enterprises specified as activities in the linear programming problem can also be modified, reflecting changes in agronomic and livestock feeding practices and in input-output relationships. The response to drainage is only partly a change in expected yields. To take optimal advantage of the increased productivity, it is necessary to make changes in the use of other inputs. After tiling, for example, it usually becomes profitable to use more fertilizer, which further increases the yield.

A revised grass hay enterprise, for example, will have a higher variable cost and a higher yield per acre. The higher yield will supply more hay to the livestock enterprises or result in more hay available for sale. The linkage of crop and livestock enterprises means that some of the benefits of tiling show up in the livestock operations.

The Objectives of the Study

The purpose of this analysis is to determine the economic impact of tiling on Northern New York dairy farms. Two closely related characteristics of the farms are considered: farm organization, i.e., the kinds and sizes of enterprises; and the level of management income.

To achieve these goals, four objectives were set:

1. To construct enterprise budgets for the crop and livestock enterprises to be considered,
2. To determine optimal enterprise organizations for alternative resource bases,

3. To determine the profitability of tiling with full and partial firm reorganization, and

4. To evaluate the results of different strategies of tiling and reorganizing the farm.

THE ANALYTICAL FRAMEWORK

The analytical framework adopted is consistent with two basic premises. The first is that the primary economic concerns in evaluating a new technology are the changes in input-output relationships. With the associated prices of the inputs and outputs, these changes determine profitability.

The second premise is that proper evaluation must be based on optimally organized and full integrated systems. Yet, the ability of the existing system to adapt and the availability of resources must be recognized as limiting the extent of reorganization possible. The farming system should be adapted to the new technology, tiling, as much as its flexibility allows. Only then can the new practices be evaluated and the best decisions made.

The conceptual model needs to have certain capabilities and characteristics. It should be an economic optimizing model capable of portraying the technological change. It should incorporate the changes in input-output relationships and show the systemic adjustments. Both occur at two levels--within individual enterprises and throughout the farm.

Economic, technical, administrative, social and ecological integration are all part of incorporating the new technology into the farming system. Integration is not a one-way process of adjusting the system around the new technology. Rather, both must be adapted to each other. Tiling can be seen as a way of adapting the soil environment to high-yielding cropping techniques. However, different tiling methodologies exist and are appropriate to different environments.

Economic integration involves optimizing benefits, given the economic environment. Technical integration links the components of the system into a coordinated, efficient whole. Administrative integration coordinates the managerial and other activities necessary to operate the system with the new technology in place. Social integration refers to the relationship between the nature of the new technology and the existing social structures, values and norms. These types of integration are variably difficult to work with. Social and ecological integration are not dealt with directly by the analysis; economic and technical integration are performed by the model and administrative integration is assumed to occur.

Farming Systems Analyzed

By visiting farmers, extension agents and Cornell staff who have worked in Northern New York, two synthetic farms representative of Northern New York were constructed, one with a stanchion barn for 60 cows, 100 acres of hay, and 75 acres of unimproved pasture and, the other with a freestall barn with 80 cows, 200 acres of tillable land, and 75 acres of pasture (Table 1).

Table 1. Synthetic Farm Resources and Production Levels of Enterprise Budgets.

Farm	Enterprise	Size	Production Levels
I. 80-cow herd; free-stall housing; milking parlor; scrape barn and spread manure daily	Dairy Cow	80 head	10, 13, 16, and 18,000 lbs. milk/year
	Heifer/ replacement	56 head	
	Total	136 head	
	Hay Crop Silage[a/]	100 acres	3.5, 5.4, 7, and 10 T/A
	Corn Silage[b/]	100 acres	8, 12, 16 and 18 T/A
	Pasture	75 acres	1.0 T/A of hay equivalent[c/]
	Homestead	25 acres	
	Total Land	300 acres	
II. 60-cow herd; stanchion housing; pipeline milking system; spread manure daily	Dairy Cow	60 head	10, 13, 16, and 18,000 lbs. milk/year
	Heifer/ replacement	42 head	
	Total	102 head	
	Dry Hay[c/]	100 acres	1.5, 2.3, 3, and 4.5 T/A
	Pasture	75 acres	1.0 T/A of hay equivalent[c/]
	Cropland	175 acres	
III. Other enterprises	High Moisture Ear Corn	50 acres	40, 60, 80, and 100 bu/A, dry shelled equivalent

[a/] 60 percent moisture.

[b/] 70 percent moisture.

[c/] 10 percent moisture.

The Effects of Tiling

In order to analyze the effects of a technological change on a farming system, it is necessary to understand the effects of the change on the components of the system. This is achieved by starting with fundamental effects on the field environment and proceeding through their biological and agricultural ramifications to the operations and dimensions of the farming system.

The physical and chemical changes in the soil made possible by tiling include faster soil heating, better aeration, reduced water-logging, improved availability of nutrients and more stable soil structure (Wesselling; Neenan, Milligan, and Swader).

These physical and biological changes have multiple effects on the farm. Machinery operating conditions in the field are better because of faster drying times and because the soil structure is more stable, leading to an improvement in timeliness of field operations and to lower operating and maintenance costs for field machinery. Improvements in drainage allow the farmer more control over scheduling of crop operations and in that manner potentially increase productivity and quality of harvested material. Early corn planting, for example, increases yields considerably. Protein and energy contents of hay crops also are sensitive to date of harvest.

Tiling has impacts on both the level and stability of yields. The variability of yields is reduced, particularly the risk of extremely low or no yields. This risk reduction has two sources: improved timeliness and better working conditions. There are also increases in production derived from better plant growth and changes in input-output relationships which favor more input use. These combine with the shift in the distribution of yields to produce a higher expected yield.

Tiling can significantly alter the combination of crop enterprises grown. Legumes can replace grass hays. Rotations with more row crops become possible, increasing the acreage available for corn. Corn grain becomes a more viable crop enterprise. Several changes occur in the quality and quantity of nutrients available from the crop enterprises. Protein and energy contents tend to be higher in legumes than in grasses. Corn silage also has a higher energy content than hay crops.

The changes in the crop enterprises have ramifications for the livestock enterprises. First, the increased productivity of the land brings a higher production capacity, which may allow an increase in herd size. The changes in cropping pattern may lead to a change in the rations fed to the cows. Better quality forage means less concentrate is required or more milk can be produced with the same quantities of forage and concentrates.

Not all of the possible changes in farm operations are considered directly in this analysis. For some, the data base was not available, while for others the impact was expected to be small. Five kinds of changes are incorporated: (1) the productive capabilities of the land resource, (2) the yields of the crop enterprises, (3) the nutrient content of the hay crops, (4) the rations fed to the livestock, and (5) the size of the herd supported by on-farm forage production.

Before tiling, the only viable use of the land not in corn is assumed to be a grass hay crop (G). After tiling, a mixed mainly legume (MML) replaces the grass. Hay and corn are rotated with the maximum amount of corn in the rotation depending on the drainage class. No corn is allowed on poorly-drained land while on well-drained land, corn can be grown six years out of every nine (Table 2).

In effect, tiling puts the farm on a new set of production functions. This change means that new optimal combinations of input and outputs are available. The main effect is to increase the expected harvested yields of the crops. This effect is portrayed by a series of enterprise budgets at different yields for the two hay crops and for corn silage (CS) and grain (CG) (Table 3).

Table 2. Maximum Years of Corn in the Rotation, by Drainage Class.

Drainage Class	Maximum Years in Corn
Well drained	6 in 9
Moderately well to well drained	5 in 8
Moderately well drained	4 in 8
Somewhat poorly drained	3 in 8
Poorly drained	0

Table 3. Crop Yields by Drainage Classes.

	Hay Crops				Corn Crops		
	G		MML		CS		CG
Drainage Class	Dry Hay	Hay Crop Silage	Dry Hay	Hay Crop Silage			
	Tons Hay Equiv.[a]				T[b]	T HEq[c]	Bu. CG Eq[d]
Well drained	3.5	3.6	4.1	4.6	16.2	5.4	90
Moderately well to well drained	3.2	3.3	3.7	4.2	15.0	5.0	83
Moderately well drained	2.8	2.9	3.3	3.7	13.5	4.5	75
Somewhat poorly drained	2.0	2.1	2.5	2.9	10.2	3.4	55
Poorly drained	1.2	1.2	1.6	1.9			

a/ At 10 percent moisture.

b/ At 70 percent moisture.

c/ 1 ton, hay equivalent, of corn silage = 3 tons, as fed.

d/ 1 bu. corn grain equivalent, 15 percent moisture = 0.0414 tons, high moisture ear corn, at 32 percent moisture.

Tiling is assumed to improve poorly drained land to moderately well drained, somewhat poorly drained land to an intermediate between moderately well and well drained and moderately well drained land to well drained. These changes were determined as a result of discussions with Swader and Thomas.

The change from grass to mixed mainly legume in the hay crops precipitates a major shift in nutrient contents. Rations and livestock enterprise budgets reflecting the nutrient qualities are taken from Wackernagel, Milligan, and Knoblauch (1979).

Drainage Technology and Costs of System Selected

Both surface and subsurface drainage systems have been suggested. The most common form of surface drainage involves land smoothing--filling in low spots to eliminate puddling and to facilitate runoff. Land smoothing is most practical in areas where the impermeability of the heavy clay soils makes tile drainage infeasible; parts of northern Jefferson County are an example.

Tile drainage systems are networks of subsurface conduits through which excess water runs to an outlet. A number of forms of conduit exist--stone drains, ceramic pipes, plastic tubes, and earth-lined tunnels made by a mole plow. In common usage, "drainage tile" refers to ceramic and plastic pipes. This convention is followed. The two types are equivalent for the purposes of this study both in terms of cost and function.

The networks of tile are either systematic or random. Systematic tiling is laid out in a grid of parallel or herringbone pattern. It is suited to uniform simple slopes which are uniformly wet. In random tiling, the lines are set out without pattern, draining just the wet spots or following the "lay of the land". Much of the region's most fertile, wettest land has almost no slope. From the technical point of view, systematic tiling is the more appropriate type for much of Northern New York.

Two methods of installing tile drainage systems are considered in this study--using a trencher and a backhoe. The former is used in the comparison of costs and benefits. Tiling with a backhoe is more expensive for the systematic grid layout and may not even be feasible if grade control is crucial. With either machine, costs increase with the stoniness of the soil.

The costs of materials depend slightly on the type of tile used and mostly on the design of the system. The amount of ditching depends on the topography, soil type and presence of existing watersheds capable of carrying away the water.

The projected costs of tiling (Table 4), based on the stated assumptions of technology, 1978 prices and the conditions and design features noted in the table are \$556/acre using a trencher and \$640/acre using a backhoe. The 50 foot spacing is narrow; even on silty and clay loams it should support the improvement in drainage class discussed earlier. Increasing spacing to 75 or 100 feet would reduce costs almost proportionately. Random tiling would be still cheaper on a per-acre basis. If alterations were made, the yield changes assumed would also need to be examined.

Table 4. Investment and Annual Costs of Tiling in Northern New York.[a/]

Item			With Trencher	With Backhoe
	Feet/ Acre	Cost/ Foot	Investment Cost Per Acre	
Trenching, tile placement and backfilling: Trencher	916	$ .35	$320.60	
Backhoes	916	.45		$412.20
Tubing: 4"	870	.23	200.10	200.10
6"	23	.50	11.50	11.50
8"	23	.95	21.85	21.85
Corrugated metal outlet pipe	0.4	4.38	1.75	1.75
Animal guard, $5/block			0.25	0.25
Total			$556.05	$647.65
			Annual Costs Per Acre	
Repairs: (1 blowout/block @ 5 years)			$ 0.50	$ 0.50
Labor: (0.1 hr/A/year @ $3.50 per hour)			0.35	0.35
Amortized investment:				
Depreciation, 40 yrs.			13.90	16.19
Interest, 7 percent of average value			19.46	22.67
Total			$ 34.21	$ 39.71

[a/] Assuming slowly permeable, gently sloping, generally stone-free soil; plastic tubing supplied by contractor; 50 ft. spacing between lines (870 linear ft./A); half of collector lines 6" and half 8"; and 200 A tiled, divided into ten equal blocks, each with a collector line.

Calculating an annual cost for the investment requires inclusion of the depreciation and interest on the investment, and maintenance of the tile lines. The annual costs are $34/acre and $39/acre for the trencher and backhoe methods. The depreciation and interest charge is based on a 40-year life of the tile. Technically this lifetime seems feasible. Tile lines put in early this century are still functional at the Miner Center, for example.

In order for tiling to be a profitable investment, the return from the increased productivity of the land must be greater than the annual cost of tiling, which, at most, is $40/acre. This is about the gross value of two-thirds of a ton of good quality hay or two to three tons of corn silage. The remainder of this study examines the use of the increased productivity of the land and the values accruing to the farmer from the different uses.

The Enterprise Budgets

The enterprise budgets encompass the first stage of the integration of tiling into the operations of the farm and its effects on individual production units. The budgets are based on multidimensional production relationships. Changing the level of one input often makes it economical to change the level of others. Among the crops, for example, tons of hay equivalent are related to soil quality, seed and labor used, fertilizer applied and fuel consumed.

Enterprise budgets were developed for different soil resources. Improved drainage is portrayed by changes in the inputs used and outputs produced. Tiling results in increased crop yields. It also has the synergistic effect of increasing returns to other inputs, making increased use of them profitable.

A beneficial adjustment associated with tiling is growing mixed mainly legume hay crops and corn silage instead of grass hay crops. The return from the substitution of a different hay crop or corn silage for the grass is not based simply on amounts of dry matter, but on energy, protein and mineral contents. Accordingly, least cost balanced rations using the different forages were formulated and became the bases of dairy budgets, used in showing the effects of tiling on the dairy livestock enterprises.

The budgets approximate recommended points on a multidimensional production surface which is an aggregate of the production functions of all of the inputs. Tiling puts the farm on a new production surface with a different optimal point. At this point, there is a different level of output and a different combination of inputs. The tile has affected the quantities and qualities of inputs used and output produced. When the levels of inputs and output have been adjusted to a new optimum, the new technology has been successfully integrated into the enterprise.

The construction procedure and details of enterprise budgets relevant to the synthetic farm with freestalls are in <u>An Economic Analysis of Northern New York Dairy Farm Enterprises: Freestall Housing Systems</u> (Wackernagel, Milligan and Knoblauch, 1979).

Profitability of Tiling

At the farming system level, optimal enterprise combinations were obtained by utilizing a linear programming model. The program solution was subject to the resources available and technical relationships among resources, inputs and products specified above. The effects of tiling on the farm as a whole are portrayed by the changes in farm organization before and after tiling and by changes in profitability. The linear programming model used was "NEWPLAN Program 65: Profitable Organization of Dairy Farm Enterprises" (Nott and Harsh), referred to hereafter as the dairy linear program. It has been adapted for use in New York (Milligan and Knoblauch).[1/] The program selects from alternative livestock and crop enterprises to maximize returns to fixed factors.

The linkages among resources and enterprises ensure that the solution is a technically integrated combination of enterprises. For example, cropland; forage production, purchases and sales; herd size; and feed requirement of the ration are all balanced so that there are no deficiencies or surpluses. Changes in the nature or size of one enterprise are reflected by changes in the others.

Land is the primary resource whose utilization is determined by the program. Labor can be viewed as either a resource or an input. Whichever it is called, its use is also determined by the program. Other input use--fertilizer, operating capital, fuel, etc.--can be determined from the number of units of the enterprise in the solution and the per-unit rate of input use in the enterprise budgets.

The linear program maximizes return over variable expenses. Fixed costs are assumed constant. Among the options analyzed are expansion of the herd and introduction of corn grain. These entail capital expenditures which became fixed costs. To incorporate these options into the analysis and to have a more meaningful measure of profitability, management income was calculated and used as the primary measure of profitability.

The theoretical basis for the use of linear programming to evaluate a change in technology lies in its ability to reflect input-output relationships in its selection of enterprises. When the technical coefficients which quantify the relationships are changed, the solution may change. In the crop enterprises, the coefficients for yield, selected variable expenses and labor requirement change with tiling. For the livestock, the quality of hay, amounts of ingredients in the ration and selected variable expenses change.

[1/] Summary information on costs and production levels for New York State are stored in the data files for NEWPLAN Program 65. The data are organized by regions within the State, based on sets of enterprise budgets constructed for each region. The information from the budgets based on the grass hay crops is stored in Region 3 of the file, while the information from the mixed mainly legume budgets is in Region 4. For further explanation of the use of this program, contact Dr. Milligan or Knoblauch.

The results from a linear programming model show optimal combinations of enterprises before and after tiling on the synthetic dairy farms representative of Northern New York. For given resource bases and management strategies, the model was solved twice, once with the pretiling technical coefficients and once with the posttiling coefficients. Comparing the two solutions shows the impact of the tile. The comparisons are made in terms of the size and combination of enterprises, profitability of the farm, values of resources, effects of different resource bases and management strategies, and labor and other input use.

The adjustments made in the farming system can also be segregated and the linear programming model repeatedly solved as they are sequentially accumulated. This leads to a disaggregation of the total benefit among its various sources: changes in yields, cropping pattern, rotation restriction, herd size and ration fed. The major sources of benefit are identified. This step-by-step reorganization also depicts one type of transition from an optimally organized untiled farm to an optimally organized tiled farm. This transition by accumulation of technical adjustments suggests preferred strategies of adapting the farming system to the better-drained land. Another type of transition--gradual installation of tile over a period of time--was not modeled, though it is an approach often used by farmers. Both the lack of available capital and a desire to install the tile between sod and row crops in the rotation inhibit complete tiling at one time. Examining this approach depends partly on the knowledge generated in this study--such as the profitability of tiling the whole farm.

THE ECONOMIC IMPACTS OF INSTALLING TILE DRAINAGE ON THE FREESTALL HOUSING FARMING SYSTEM

This section presents and discusses the results of the analyses of installing tile drainage on the synthetic farm with 200 crop acres and freestall facilities for 80 cows. The first part describes the base situation in detail and then considers several variations in which one or more parameters of the farm are altered. The second part contains a disaggregation of the benefits from tiling due to the individual adjustments in the organization and operation of the farm. The last part relates the findings to the decisions which farmers are likely to face with regard to tiling.

The Dimensions of the Base Farm

The base farm portrays a typical Northern New York farm likely to be installing tile drainage. Grass is grown before and mixed mainly legume is grown after tiling. Milk production is 13,000 pounds per year. The land base before drainage consists of 150 acres of somewhat poorly drained and 50 acres of moderately well-drained land. After tiling, the drainage classes improve to an intermediate between moderately well and well drained for the larger area, and to well drained for the 50 acres. The input and output prices used in the enterprise and in this analysis are summarized in Table 5.[1/]

The Results of Tiling the Representative Farm

The most profitable organizations of enterprises for the base farm before and after the installation of the tile are summarized in Table 6. The dairy herd is maintained at the capacity of 80 cows. The percent hay in the dairy ration refers to the proportion of dry matter in the forage mixture which is hay crop silage, the remainder being corn silage. The proportion drops from two-thirds to one-third with tiling. The corn silage proportions are the maximum possible both before and after the improvement in drainage.

Heifer numbers are determined by the herd size and the replacement rate (30 percent). With 80 milkers, 24 heifers must enter the herd each year.

The improved drainage produces a shift of land from the hay crop enterprises to the corn silage enterprises, nearly doubling the acreage of corn silage. On the better drained land, the maximum acreage of corn is planted; due to the partial relaxation of the rotation restriction after tiling, corn increases 8 acres there. On the somewhat poorly drained land, there is a small reduction of the hay crop silage after tiling, 16 acres.

The above enterprise changes result in some large changes in feed purchases and sales. The initial forage deficit is converted to a surplus. The switch from 58 tons of hay purchased to 280 tons of hay sold illustrates the increase in productivity of the farm and the increased usage of corn silage in the ration. The reduction in corn grain purchases reflects the improved quality of the hay crop silage and the increased proportion of corn silage in the roughage. Soybean oil meal purchases decline only slightly because the decrease in hay content in the ration counteracts the higher protein content of the hay crop.

Labor use shows increases of 156 hours, or 2 percent, as a result of the enterprise reorganization. This increase results from the higher labor inputs associated with higher yields. The change does lead to some reshaping of the distribution of labor usage (Figure 2). Before tiling the primary peak is in midsummer, while a secondary peak appears in the fall. With tiling and subsequent enterprise reorganization, the main peak drops a little and the secondary peak rises and broadens with the second hay harvest and larger corn silage crop. Overall, labor shifts away from the middle of the summer and into the late spring and early fall.

[1/] Buildings, machinery complements, and detailed enterprise budgets are contained in the companion publication (Wackernagel, Milligan and Knoblauch, 1979). The crop enterprise budget information used in the analysis is summarized in Appendix Table 1. The least cost balanced rations and livestock enterprise budgets are summarized in Appendix Tables 2, 3, and 4.

Table 5. Input and Output Prices.

Item	Price, Value, or Cost Selling	Buying
	(dollars)	
Capital: Long-term		9%
Short-term		7%
Crops:		
Corn		
High moisture ear corn: HMEC	57.25/T[a/]	67.39/T
	2.37/bu,CEq[b/]	2.79/bu,CEq
Silage: CS	18.19/T	23.40/T
Dry hay		
Grass: G(DH)	45/T	60/T
Mixed mainly legume: MML(DH)	55/T	70/T
Hay crop silage		
Grass: G(H)	19.29/T[c/]	25.40/T
Mixed mainly legume: MML(H)	23.57/T	29.60/T
Pasture[d/]		12/A
Electricity[d/]		.04/kw-hr.
Feeds and minerals:		
Corn, shelled		2.79/bu.
Dicalcium-phosphate: Di-Cal		18/cwt.
Limestone		2/cwt.
Magnesium oxide: MgOx		18/cwt.
Milk replacer		35/cwt.
Monosodium phosphate: Mono-phos		40/cwt.
Salt, trace mineral		5/cwt.
Soybean oil meal		10/cwt.
Fertilizers:		
Nitrogen: N		0.20/lb.
Phosphate: P_2O_5		0.16/lb.
Potassium: K_2O		0.10/lb.
Fuel, Diesel		0.50/gal.
Labor		3.50/hr.
Land: Crop		450-575/A
Pasture		100/A
Lime		14/T (spread)
Milk and livestock:		
Calves	35.00	
Cows and heifers	450-700	
Culls	286	
Milk	9.52/cwt.	
Seed:		
Corn (per 80,000 seeds)		40
Reed canary grass		2.25/lb.
Timothy		0.75/lb.
Trefoil		4.50/lb.

a/ From budget publication.

b/ CEq stands for corn equivalent.

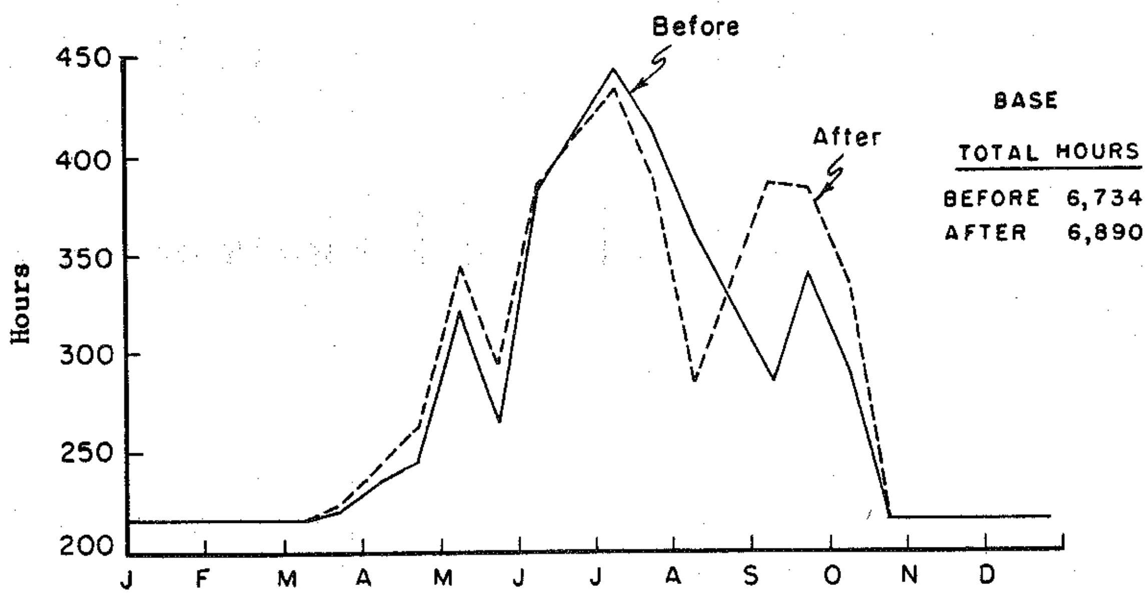
c/ Selling prices for hay crop silage are based on harvesting as dry hay, with differences in harvesting losses taken into account.

d/ These costs are not used directly in the budgets or the dairy linear program.

Table 6. Change in Profitability and Enterprise Organization Resulting from the Investment in Tiling the Representative Farm.

	Base Before	Base After	Change
Return Over Variable Expenses ($)	21,285	42,124	20,839
Fixed Expenses ($)	52,688	59,530	6,842
Management Income ($)	-31,403	-17,406	13,997
Enterprises:			
Dairy, number of cows	80	80	0
percent hay in ration	67	33	-34
Heifer, number of heifers	56	56	0
percent hay in ration	67	33	-34
Hay crop silage (acres)			
better drained land	25	17	-8
less well-drained land	128	112	-16
Corn silage (acres)			
better drained land	25	33	8
less well-drained land	22	38	16
Feed Purchases:			
Hay (T)	58	0	-58
Corn grain (bu.)	6,413	3,778	-2,635
Soybean oil meal (cwt.)	50	49	-1
Feed Sales, Hay (T)	0	280	280
Labor, Annual (hrs.)	6,734	6,890	156
Shadow Prices ($)			
Cow	128	266	138
Acre, better drained	75	108	33
less well-drained	42	95	53

Figure 2. Monthly Labor Distribution Before and After the Enterprise Reorganization Resulting from Tiling.



Return over variable expenses increases from $21,285 to $42,124, an increase of $20,839. Deducting the fixed expenses of the synthetic farm ($52,688), and the annual costs associated with installing and maintaining the tile ($6,842), reveals management income. It is negative both with and without tiling. In interpreting this, it should be noted that the budgets cost all investments at new prices and land at current value; all labor including operator and family hours is charged $3.50/hour; and a return on investment capital of 7 percent is charged. Though negative, management income rises nearly $14,000 with tiling. This increase represents an annual net return of tiling to the owner, after deducting the fixed costs.

The shadow price for a restriction in linear programming is the increase in return which would result from one more unit of the resource. The changes in land productivity, hay crop, ration and other adjustments which follow tiling more than double the value of an additional cow. Without tiling, another acre of better-drained land would add $75 to return over variable expenses. After the drainage improvement, an additional acre would be worth $108 in return over variable costs. Additional acres of the poorer land would go directly into hay production, increasing income before and after tiling $42 and $95, respectively. This change reflects the greater increase in productivity which occurs on land of lower drainage classes.

A partial budget is utilized to further analyze the drainage investment (Table 7). After tiling, variable expenses in the crop enterprises increase by $4,834. Input usage is increased on all crops and the corn silage acreage is enlarged; corn crops have higher expenses per acre than hay crops. Although variable expenses for livestock increase slightly, purchased feed costs decline by $10,992, for a net reduction of livestock and feed costs. Another important addition is the sale of $15,404 of surplus hay. These adjustments come from increased productivity and from reorganization of the farming operations.

In sum, the installation of the tile--leading to higher yields, larger corn silage acreage, and higher corn silage and lower concentrate contents in the ration--brings about an increase in return over variable expense of $20,839. When the annual expense of tiling ($6,842) is deducted, there is a net increase in management income of $13,997 for the base farm with 80 cows.

Sensitivity Analyses

Several dimensions of the farming system--initial resource levels, production levels, management strategies--were varied to further explore the profitability of investments in drainage. Three different combinations of drainage classes are used to show the effects of initial drainage status. Three milk production levels are used. A number of crop options are included: hay crop and corn silage forage systems, a corn grain enterprise, and grass hay crops after tiling. Herd size is allowed to rise to the level which on-farm forage production can support. Combinations of changes are also considered to show synergistic effects.

In order to explore these effects, they were varied one-by-one using the same base model. Two comparisons deal with alternative means of using the surplus forage production after tiling; others compare low, middle (i.e., base), and high levels of milk production and initial drainage status of the farm. The results of the single factor changes are presented in Table 8.

Alternative Utilization of Added Crop Productivity

In the base analysis, forage production after tiling exceeds the requirements of the herd by 280 tons of hay. This excess capacity can be used to produce corn grain or forage to support more cows. Two analyses are designed to test these options. In the first high moisture ear corn is grown and substituted for purchased grain. In the second the maximum number of cows is the number that can be fed from farm-produced forages. At the price levels assumed, neither of these strategies is a good economic alternative to the base and its strategy of selling hay.

Addition of Corn Grain Enterprise

The corn grain enterprise returns $384 over variable costs, much less than the $2,214 annual fixed cost of the new investment required for a snapper head and silo. Corn grain acreage comes from the hay crop. Before tiling, the consequence is a larger hay deficit and afterwards a smaller hay surplus for sale. The shadow prices of both land and cows are not significantly different from those in the base, suggesting that the corn grain enterprise is comparable to the others in terms of returns over variable expenses.

Table 7. Income and Expense Changes Resulting from the Drainage Investment.

Added Costs:	
Labor: 156 hours @ $3.50	$ 546.00
Dairy Variable Expenses	140.80
Heifer Variable Expenses	33.36
Hay Crops: Better-drained land	55.00
Less well-drained land	2,513.52
Corn Silage: Better-drained land	773.00
Less well-drained land	1,492.92
	$ 5,554.60
Reduced Costs:	
Hay Purchases: 58.13 T @ $60	$ 3,487.80
Corn Grain Purchases: 2635.03 bu. @ $2.79	7,351.73
Soybean Oil Meal Purchases: 0.76 T @ $200	152.00
	$ 10,991.53
Added Benefits:	
Hay Sales: 280.08 T @ $55	$ 15,404.40
Total Change in Income	$ 20,841.33[a]
Present Value of the Increase in Income over 40 Years @ 7 Percent	$276,517.00
Tile Installation Costs	111,210.00
Net Benefit from Drainage	165,307.00
Internal Rate of Return on Investment in Tiling	18.6%

[a] Figures do not agree exactly with those presented in other tables because of rounding.

Table 8. Changes in Profitability and Enterprise Organization Resulting from the Investment in Tiling When Selected Factors are Altered on the Representative Farm.

	Base			Corn Grain			Variable Herd Size			Low Milk Production		
	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-31,403	-17,406	13,997	-33,381	-19,236	14,145	-28,568	-23,929	4,639	-42,441	-28,483	13,958
Internal Rate of Return			18.6			18.7						18.1
Enterprises:												
Dairy: herd size	80	80	0	80	80	0	69	135	66	66	80	14
% hay in ration	67	33	-34	67	33	-34	67	33	-34	67	33	-34
Hay Crops, A: I[a]	25	17	-8	25	17	-8	25	22	-3	25	17	-8
II	128	112	-16	94	63	-31	136	56	-80	136	110	-26
Corn Silage, A: I	25	33	8	0	0	0	25	28	3	25	33	8
II	22	38	16	55	73	18	14	94	80	14	40	26
Corn Grain, A: I				25	33	8						
II				1	14	13						
Feed Purchases:												
Hay, T	58	0	-58	116	0	-116				0	0	0
Corn grain, bu.	6,413	3,778	-2,635	4,642	0	-4,642	5,532	6,385	853	3,940	2,180	-1,760
Soy oil meal, T.	50	49	-1	50	49	-1	43	83	40	28	34	6
Feed Sales:												
Hay, T	0	280	280	0	114	114	0	0	0	0	267	267
Corn silage, T.	0	0	0	0	0	0	0	0	0	0	0	0
Annual Labor, Hrs.	6,734	6,890	156	6,682	6,761	79	6,011	10,472	4,461	5,346	6,320	974
Shadow Prices:												
Dairy cow	128	266	138	125	270	145	0	0	0	0	120	120
Better drained land	75	108	33	84	108	24	129	299	170	66	108	42
Less well-drained land	42	95	53	47	95	48	82	272	190	36	95	59

[a] Crop enterprises on the better and less-well drained land are indicated by "I" and "II" respectively.

Table 8. (Continued)

	High Milk Production			Poor Initial Drainage			Better Initial Drainage		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-20,616	-7,161	13,455	39,372	-20,211	19,161	-27,916	-15,997	11,919
Internal Rate of Return			18.1			23.2			16.7
Enterprises:									
Dairy: herd size	80	80	0	80	80	0	80	80	0
% hay in ration	67	33	-34	93	33	-60	67	33	-34
Hay Crops, A: I[a]	25	17	-8	31	19	-12	143	132	-11
II	131	116	-15	150	103	-47			
Corn Silage, A: I	25	33	8	19	31	12	57	68	11
II	19	34	15		47	47			
Corn Grain, A: I									
II									
Feed Purchases:									
Hay, T	39	0	-39	211	0	-211	0	0	0
Corn grain, bu.	8,078	5,583	-2,495	7,555	3,778	-3,777	6,413	3,778	-2,635
Soy oil meal, T.	66	65	-1	42	49	7	50	49	-1
Feed Sales:									
Hay, T	0	298	298	0	209	209	0	326	326
Corn silage, T.	0	0	0	0	0	0	182	0	-182
Labor, Annual, Hrs.	7,454	7,614	160	6,590	6,859	269	6,806	6,904	98
Shadow Prices:									
Dairy cow	263	394	131	103	264	161	175	266	91
Better drained land	75	108	33	78	97	19	51	108	57
Less well-drained land	42	95	53	5	79	74			

[a] Crop enterprises on the better and less-well drained land are indicated by "I" and "II" respectively.

Herd Size Dependent on Forage Producing Capability

The primary object of the variable herd size analysis is to investigate the potential effect of the change in the forage-producing capability of the farm. As a result of the tile, forage can be produced for an additional 66 cows. Because of the assumptions used in the livestock budgets, income from cows does not cover all variable and fixed expenses. Consequently, the expansion actually produces a smaller change in management income than the base. The benefit in increased land productivity is diminished by the failure of the expansion to cover all costs of the additional cows. The significant result is the substantial increase in potential herd size. This expansion involves a large shift of land, 83 acres, from hay crop into corn silage, and large increases in labor and soybean oil meal purchases. Corn grain purchases rise slightly because the change in herd size is proportionally larger than the decrease in requirement per cow.

The distribution of labor is shifted upward and rearranged (Figure 3). The after-tiling distribution shows a broad plateau of labor from late April to early July for planting and first hay cutting operations. The major peak occurs in the second half of September, with the harvest of the corn silage. Before tiling, the hay crop harvest dominates with only a small peak during September.

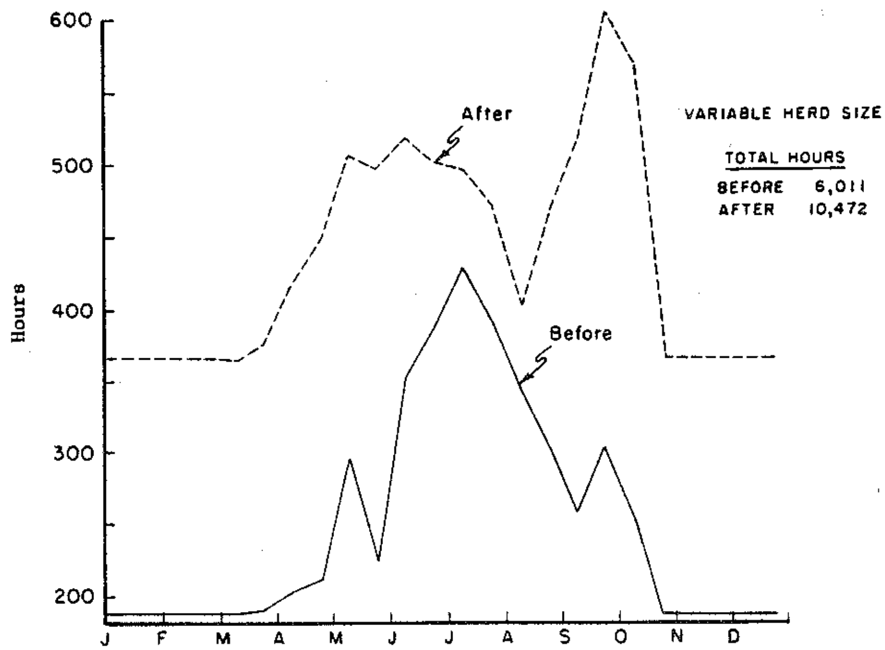
The shadow prices for land show how much an additional acre would increase return over variable expenses (Table 8). For the better-drained land, they rise from $129 to $299/acre, much higher than the $75 and $108/acre of the base, where added production would just reduce purchases or increase sales of hay. The values of the less well-drained land are lower, but they change more, reflecting the lower productivity but larger response to tiling.

Effect of Milk Production

On a dairy farm, income is derived from crops indirectly, through the production of milk. Accordingly, the effects of the level of milk production on the benefit received from tiling is investigated using production levels of 10,000, 13,000 (base farm) and 16,000 pounds per cow. Neither the lower nor higher milk production level resulted in increased return from tiling (Table 8). The change in management income resulting from the tile is less with high production than in the base because the cows utilize less roughage since requirements decline with increasing production. At low production, the advantage of the mixed mainly legume hay over the grass is less because the cow's nutrient requirements are more easily met. In addition, prior to tiling the herd size is limited to that which can be supported by on-farm forage production. Expansion absorbs part of the benefit of the tile because of the ownership costs of the additional cows.

The shadow prices illustrate the impact of milk production levels. The shadow prices of a cow increase both as production and drainage improve, ranging from $0, at low production before tiling, to $394 at high production after tiling. The difference in value reflects the relationships among forage requirement, milk production and profitability. The effect of tiling

Figure 3. Monthly Labor Distribution Before and After Tiling When Herd Size is Dependent on Forage Producing Capabilities.



is to reduce the per ton cost of forage production. The shadow prices of land are functions of the crop produced and the way it is used--to displace purchased feeds or to sell.

Effect of Initial Drainage Condition

Another sensitivity analysis relates to initial drainage conditions on the farm. Poorer and better drainage are compared with the base. The farm with poorer initial drainage has 50 acres of somewhat poorly drained and 150 acres of poorly-drained land. With better initial drainage, the farm has 200 acres of moderately well drained land.

By far the most significant difference among the three is in the changes in management income which increases by $19,161 with poorer drainage, $13,997 in the base, and $11,919 with better drainage. A major factor in the greater change with poorer drainage is the larger decrease in percent hay in the ration from 93 to 33 percent. Hay purchases, also, are reduced by a larger amount. The land use, feed purchases and sales interaction follows a logical pattern. The area of land switched out of hay crops and into corn silage decreases with better initial drainage because more corn is grown before tiling when the drainage is better. By selling a larger proportion of the increased crop production, the better-drained farm receives less benefit than the more poorly drained farm.

Summary

Considering all single-factor variations, the biggest impact on the profitability of tiling comes from changes in initial drainage conditions. The range between poorer and better conditions is $7,242. Milk production affects the returns less, with a range of only $542. The impacts of drainage conditions and production levels are also demonstrated by the changes in the value of an additional cow. Again, drainage has more effect than milk production; the change in the shadow price of a cow is $91 with better drainage and $161 with poorer drainage. The impact of production level is smaller, with $120 at low and $138 at base-level production. Alternative use of the new production capacity is not a good option. Forty-seven acres of corn grain increases the return to tiling by $148, but returns do not cover the fixed costs of the grain enterprise. Under the conditions assumed, the increase in income is $9,358 lower than the base when the herd size varies. However, with favorable changes in the economic environment, tiling would facilitate expansion. The results portray the enterprise changes required to add a corn grain enterprise or to add more cows.

Sensitivity Analysis: Interactions Among Variables

It is expected that the variables will have synergistic effects on the farm organization and the returns to tiling. In order to further explore this, eleven other situations are analyzed, with two or more of the variables changed from the base levels. These changes fall into two groups, the first exploring effects of different milk production levels and the second, dealing more directly with the crops--cropping strategies and initial drainage status. Of course, there is some overlap between the groups.

Milk Production Levels

Milk production level affects feed requirements suggesting an interaction between crops grown and the production level of the herd. The results show the effects of milk production in combination with growing corn grain, different drainage levels and the variable herd size. The data on farm organization and shadow prices are found in Table 9.

Milk Production and Corn Grain Enterprise

The results are similar to that of the single factor variation in milk production level. Management income increases most at the base production level and less at low and high production. At the low production level, the nutrient requirements of the cows are relatively small and the farm sells more hay than at the other production levels. The conversion from the grass-based to the mixed mainly legume-based forage may also be less profitable at this level. The combined effect of these factors is a reduction in the benefit of tiling when production is low. At the high milk production level, the increase in management income from tiling is $475 less than with a corn grain added at the base production level.

Table 9. Changes in Profitability and Enterprise Organization Resulting from the Investment in Tiling when Selected Factors in Combination with Milk Production are Altered.

	Base			Low Milk Production and Corn Grain			High Milk Production and Corn Grain		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-31,403	-17,406	13,997	-42,859	-30,485	12,374	-23,172	- 9,502	13,670
Internal Rate of Return			18.6			25.1			18.3
Enterprises:									
Dairy: herd size	80	80	0	50	80	30	80	80	0
% hay in ration	67	33	-34	67	33	-34	67	33	-34
Hay Crops, A: I[a]	25	17	- 8	25	17	- 8	25	17	- 8
II	128	112	-16	94	81	-13	94	56	-38
Corn Silage, A: I	25	33	8	0	7	7	0	0	0
II	22	38	16	36	69	33	52	70	18
Corn Grain, A: I				25	26	1	25	33	8
II				20	0	-20	4	24	20
Feed Purchases:									
Hay, T	58	0	-58	0	0	0	100	0	-100
Corn grain, bu.	6,413	3,778	- 2,635	241	0	-241	6,178	1,037	- 5,141
Soy oil meal, T.	50	49	-1	21	34	13	66	65	-1
Feed Sales:									
Hay, T	0	280	280	0	171	171	0	97	97
Corn Silage, T.	0	0	0	0	0	0	0	0	0
Annual Labor, Hrs.	6,734	6,890	156	4,312	6,251	1,939	7,399	7,458	59
Shadow Prices:									
Dairy cow	128	266	138	0	123	123	260	387	127
Better drained land	75	108	33	84	108	24	84	117	33
Less well drained land	42	95	53	47	95	48	47	103	56

[a] Crop enterprises on the better and less well-drained land are indicated by "I" and "II" respectively.

Table 9. (Continued)

	Low Milk Production and Poorer Drainage			High Milk Production and Better Drainage			Low Milk Production and Variable Herd Size			High Milk Production and Variable Herd Size		
	Before	After	Change	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-47,201	-31,824	15,377	-17,301	-5,754	11,547	-37,589	-42,526	-4,937	-19,543	- 6,479	13,064
Internal Rate of Return			19.8			16.4						
Enterprise:												
Dairy: herd size	26	80	54	80	80	0	66	131	65	72	141	69
% hay in ration	67	33	-34	67	33	-34	67	33	-34	67	33	-34
Hay Crops, A: I[a/]	31	19	-12	136	135	- 1	25	22	- 3	25	23	- 2
II	65	100	35				136	56	-80	136	56	-80
Corn Silage, A: I	19	31	12	64	65	1	25	28	3	25	28	3
II	0	50	50				14	94	80	14	94	80
Corn Grain, A: I												
II												
Feed Purchases:												
Hay, T	0	0	0	0	0	0	0	0	0	0	0	0
Corn grain, bu.	1,579	2,180	601	8,078	5,583	-2,495	3,940	3,567	-373	7,306	9,869	2,563
Soy oil meal, T.	11	34	23	66	65	-1	28	56	28	59	115	56
Feed Sales:												
Hay, T,	0	196	196	0	344	344	0	0	0	0	0	0
Corn silage, T.	0	0	0	281	0	-281	0	0	0	0	0	0
Annual Labor, Hrs.	2,350	6,290	3,940	7,532	7,626	94	5,346	9,270	3,924	6,882	12,168	5,286
Shadow Prices:												
Dairy cow	0	118	118	308	395	87	0	0	0	0	0	0
Better drained land	45	97	52	51	108	57	66	192	126	191	404	213
Less well-drained land	0	79	79				36	173	137	129	370	241

This small different result eminates from a greater change in corn grain acreages at higher milk production. The corn grain response to tile is slightly less than the response in hay crops.

At high production, introduction of a corn grain enterprise increases the benefit from tiling by $215 while at the middle level by $148 and at low production it decreases by $1,584. The grain enterprise, therefore, shows a more profitable response to tiling when milk production is high. In general, the role a corn grain enterprise plays and the benefits derived from tiling to support it increase with the production level of the cows.

Milk Production and Variable Herd Size

The analysis of the interaction between expansion of the herd and milk production level shows that both farm income and returns to tiling increase with higher production. This response results from the greater profitability of higher milk production and from the inverse relationship between milk production and forage requirement which means that the increase in crop production can support a greater expansion of the herd.

Milk Production and Initial Drainage Condition

To look at the interaction between milk production and initial drainage status, low production with poorer drainage, the base, and high production with better drainage are compared. The low production/poor drainage farm is extremely unprofitable. However, tiling is very profitable in this situation. Tiling makes it possible to increase the herd size from 26 to the limit, 80, fully utilizing the farm's facilities. Notably, not all land resources are used. Before tiling, only 65 of 150 acres of the less well drained land is used. This is the only situation analyzed in which land is left unused. The herd size is limited by the amount of corn silage which can be produced on the farm because variable expenses in the dairy cow enterprise are not covered in rations with less than 33 percent corn silage.

The combination effect of better drainage and high production is roughly additive in both farm income and relative benefit from tiling. The benefit from tiling, i.e., the change in management income is lower than for either high production or better drainage. Less of the benefit at high production is in using the hay crop and corn silage to produce milk and the improvement of drainage is smaller when the initial conditions are better.

Summary

The level of milk production does influence the returns to tiling and the optimal farm organization. Comparisons of the change in shadow prices for land in the three variable herd size situations show the value of tiling in the derived milk production. An additional acre of the better land increases in value most with high and least with low production. This is for land put to its most profitable use--producing forage for feed. On the farm organization side, production level influences forage requirements of the ration and through them the selection of crops grown and the size of the surplus forage capacity.

Crop Enterprise Constraints

The interactions examined in this section relate to crop enterprise selection and initial drainage status. The analysis concentrates on the addition of corn grain under different circumstances, the continued use of grass hay crops after tiling, and the number of cows the farm can supply with forage (Table 10).

Initial Drainage Status and Corn Grain Enterprise

The impact of the corn grain enterprise depends partly on the availability of land beyond that needed to produce forages. Since forage sufficiency depends partly on yield level, the profitability of a corn grain enterprise with poorer, base, and better drainage conditions is analyzed. Farm profitability increases with improvements in drainage, but the effect of tiling is greatest when the drainage is worst. Crop enterprise combination is a function of production capacity, ration requirements and rotation restrictions. Hay crop acreage declines as yields increase and as tiling is introduced, until the grain requirement is met. Higher yields then lead to a reduction in the area of corn grain, leaving more to be planted in hay for sales. Comparing changes in management income in similar farms with and without corn grain shows nearly equal advantages to the grain at low and base yields. At the high yields, the benefit from tiling is $733 smaller with grain than without because of differences in enterprises included and production capacity of the land. Tiling is more profitable on low-yielding farms with corn grain than on their high-yielding counterparts where a larger part of the grain requirement is produced before tiling.

For feed production, purchasing and sales, greater shifts out of hay crops occur with poorer drainage, reflecting the differences in rotation restrictions. With poorer and base drainage conditions, hay crops are at minimum and neither the grain nor the hay requirement of the herd is met by on-farm production before tiling. With better drainage all the grain needed can be produced and the extra land is used to grow hay to sell after tiling.

Grass Hay Crop and Corn Grain Enterprise

Tiling in this situation is an attempt to increase the farm's ability to utilize corn crops while continuing to grow grass hay crops. Though the profit from tiling in this situation is small, $2,423, it suggests that tiling would pay if the grass were not replaced by the mixed mainly legume and the farm had the facilities necessary for a corn grain enterprise. A grass forage mixture with a higher corn silage content would probably be an even better alternative. The higher grain requirement of the grass-based ration leads to a larger reallocation of land to grain than when grain is combined with a mixed mainly legume forage after tiling.

As an example of cropping patterns which include corn grain, the labor distribution for this analysis is shown in Figure 4. In the after tiling plot, there is an early season plateau corresponding to hay crop and corn planting followed by hay crop harvest, as in the corn silage dominated system. After the lower labor use in August, a fall peak follows including the second hay cutting, silage harvest and grain harvest.

Table 10. Changes in Profitability and Enterprise Organization Resulting from the Investment in Tiling when Factors are Altered in Combination with Crop Enterprise Constraints.

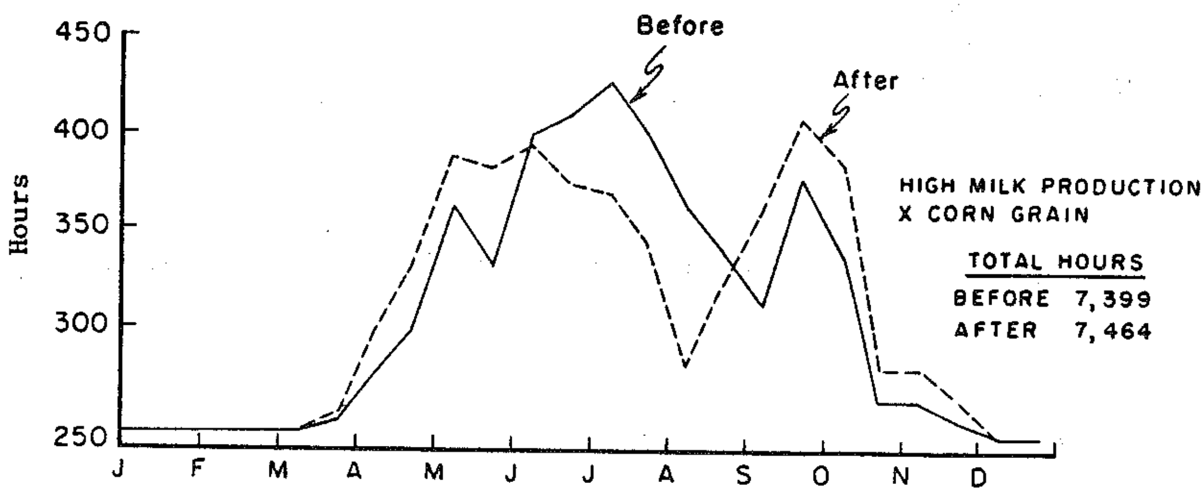
	Base			Poorer Drainage and Corn Grain			Better Drainage and Corn Grain		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-31403	-17,406	13,997	-41,586	-22,276	19,310	-28,985	-17,799	11,186
Internal Rate of Return			18.6			23.2			16.7
Enterprises:									
Dairy: herd size	80	80	0	80	80	0	80	80	0
% hay in ration	67	33	-34	93	33	-60	67	33	-34
Hay Crops, A: I[a]	25	17	-8	31	19	-12	100	86	-14
II	128	112	-16	150	75	-75			
Corn Silage, A: I	25	33	8	19	6	-13	42	68	26
II	22	38	16	0	75	75			
Corn Grain, A: I				0	25	25	59	46	-13
II					0	0			
Feed Purchases:									
Hay, T	58	0	-58	211	0	-211	99	0	-99
Corn grain, bu.	6,413	3,778	- 2,635	7,555	1,859	- 5,696	2,395	0	-2,395
Soy oil meal, T.	50	49	-1	42	49	7	50	49	-1
Feed Sales:									
Hay, T	0	280	280	0	126	126	0	158	158
Corn silage, T.	0	0	0	0	0	0	0	0	0
Annual Labor, Hrs.	6,734	6,890	156	6,590	6,793	203	6,663	6,779	116
Shadow Prices:									
Dairy cow	128	266	138	103	259	156	123	271	148
Better drained land	75	108	33	78	103	25	84	108	24
Less well drained land	42	95	53	5	84	79			

[a] Crop enterprises on the better and less well-drained land are indicated by "I" and "II" respectively.

Table 10. (Continued)

	Grass (After) and Corn Grain			Poorer Drainage and Variable Herd Size			Better Drainage and Variable Herd Size		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-34,241	-31,818	2,423	-28,631	-25,760	2,871	-29,427	-23,690	5,737
Internal Rate of Return			7.8						
Enterprises:									
Dairy: herd size	80	80	0	42	120	78	87	144	57
% hay in ration	67	67	0	81	41	-40	67	33	-34
Hay Crops, A: I[a/]	25	17	- 8	31	19	-12	155	78	-77
II	55	37	-18	150	75	-75			
Corn Silage, A: I	0	0	0	19	31	12	45	122	77
II	55	37	-18		75	75			
Corn Grain, A: I	25	33	8						
II	1	49	48						
Feed Purchases:									
Hay, T	116	113	- 3	0	0	0	0	0	0
Corn, grain, bu.	4,642	0	- 4,642	3,703	6,237	2,534	6,957	6,786	-171
Soy oil meal, T.	50	50	0	24	66	42	54	88	34
Feed Sales:									
Hay, T	0	0	0	0	0	0	0	0	0
Corn silage, T.	0	0	0	0	0	0	0	0	0
Annual Labor, Hrs.	6,682	6,645	-37	4,128	9,435	5,307	7,240	11,041	3,801
Shadow Prices:									
Dairy cow	125	150	25	0	0	0	0	0	0
Better drained land	84	97	13	117	306	189	126	299	173
Less well drained land	47	85	38	23	267	244			

Figure 4. Labor Distribution: Cropping Pattern Including Corn Grain.



The peak labor period is the same as in the corn silage system, the second half of September, but the peak is broader and extends crop labor later into the fall. Before tiling, the area of corn crops is smaller, shifting the balance of labor back into the summer.

Initial Drainage Status and Variable Herd Size

A last set of analyses looks at the interaction between drainage status and carrying capacity. The inherently higher profitability of higher yields dominates the income picture, both for the whole farm and for tiling. Profitability of tiling, however, is much more stable with respect to drainage status than it is with milk production. The range is $2,865. Herd sizes are smaller at lower yields, but increase with the tiling-produced higher yields. The poor drainage farm is bound by rotation restrictions to rations with higher hay contents than the minimum and shows greater shifts of land out of hay crop silage.

A Summary of the Effects of Tiling

To summarize the effects of tiling under different resource situations and management strategies, the scenarios are ranked by changes in management income (Table 11). The largest changes are received by situations with poorer drainage and the smallest by those with better initial drainage. The range of benefit from poorer to better drainage is $7,925. For milk production, the range between base and high levels is $592.

Poorer and better drainage are on opposite sides of the base, a symmetry which demonstrates the phenomenon of diminishing marginal returns to drainage improvement. A given amount of tiling produces a bigger benefit

Table 11. Ranks of Analyses by Change in Management Income as a Result of Tiling.

Rank	Analysis	Change in Management Income
1	Poorer Drainage and Corn Grain	$19,310
2	Poorer Drainage	19,161
3	Low Milk Production and Poorer Drainage	15,337
4	Corn Grain	14,145
5	Base	13,997
6	Low Milk Production	13,958
7	High Milk Production and Corn Grain	13,620
8	High Milk Production	13,405
9	Low Milk Production and Corn Grain	12,374
10	Better Drainage	11,919
11	High Milk Production and Better Drainage	11,547
12	Better Drainage and Corn Grain	11,186
13	Grass After Tiling and Corn Grain	2,423

when applied to land with worse drainage than to land with better drainage. Both low and high milk production receive smaller benefits than the base. This reduction in benefits results from the lower profitability of feeding the forage to the cows in the former and the smaller roughage requirement in the latter case.

In terms of farm organization, tiling tends to bring about an increase in the area of corn crops, with preference for corn silage. The increase is inversely related to both the milk production of the herd and to the initial drainage of the land. Pretiling deficits of forage are converted into surpluses (with a few exceptions), which are sold as dry hay.

The costs associated with moving from one stage to the other are for: (1) installing and maintaining the tile, and (2) higher crop expenses. The major dollar benefits come from reduced corn grain and hay purchases and from sales of surplus hay.

Disaggregation of Benefits

So far, the analysis has looked at the synthetic farm before and after tiling. This approach reflects the primary economic concern of first determining whether the final result is worth the cost. However, between the two terminal states lies a process of transition, occurring over time. The area tiled expands from none at all to the whole farm. There is also a technical transition--an accumulation of adjustments in farm operations, which leads to a final stage of full integration of the new technology into the farm. Both types occur, usually with much overlapping. This part of the study focuses on the latter.

Using two of the situations analyzed, the technical transition is studied and provides information on three matters crucial to the management of the tiling process. First, it is important that the farm survive the transition economically. There is a gap between paying the costs and realizing the full benefit, or even realizing enough of it to break even. It is useful to know what cash flows are expected and helpful to know if it will be necessary to proceed immediately to full adoption and integration or if it is possible to proceed step-by-step. Second, it is useful to identify the sources of benefit--which particular adjustment has the biggest pay-off. Finally, it is important to know how the transition should be organized--in what order the adjustments should be made.

Two closely interrelated concepts underlie this examination of transitional states--partial integration and suboptimality. For some period of time, the farm will be less than fully adapted to the improved drainage and it will not be taking maximum advantage of all technically feasible options at all times. This will result in less income than is potentially possible. Knowing the extent of this decrease helps the manager to decide how soon to move further in the transition.

The transition is portrayed by separating the adjustments made between the before and after tiling states and then considering them one by one. The sequence of changes made is: (1) raise the yields, (2) replace the grass hay crop with mixed mainly legume, and (3) change the rotation restriction.

In determining the yield effect, the same hay crop is grown, but yields are raised to the post-tiling level. This actually represents a complex of adjustments and benefits. First, it includes most of the change in biological yield potential of the land. It also includes altered levels of input application, some of the improvement in soil workability, some of the risk reduction, and a rearrangement of the cropping pattern. These are fairly direct causes or results of the higher yields.

The second step, the change from grass to mixed mainly legume hay crop, also represents multiple adjustments and benefits. A change in the crop capabilities of the land allows the new hay and its new input levels, slightly higher yields and another optimal reorganization of the cropping pattern. The dairy ration undergoes two alterations. The mixed mainly legume hay crop silage is substituted for the grass in the ration and the option to reduce the hay content below 67 percent is introduced.

The restriction on the number of years of corn in the rotation is changed to represent the improvement in the stability of the soil and the associated risk reduction.

Two disaggregations are performed: (1) the base farm and (2) adding a corn grain enterprise. Farm organization summaries and shadow prices for each stage are presented in Tables 12 and 13. Changes in key parameters of each analysis are also shown in a two-part figure with the first relating income and the major cash expense items, i.e., input and outputs; and the second relating income and enterprise combinations. In order to fit all the variables on the same scale, they are converted to percentages. Most are percents of the maximum value the parameter takes in the sequence. Thus, percent maximum crop expenses is the ratio of the crop expenses at each stage to the highest crop expenses in the sequence.

The Disaggregation of the Base Analysis

The dollar value of the benefits from tiling the base farm is represented in Figure 5a by the line labeled "percent maximum accumulated benefit". It shows about one-third of the total benefit coming from the increase in yields and essentially all the rest from the conversion to the mixed mainly legume hay crop and rations.

At Stage II,[1/] with the higher yields, the major changes are the elimination of hay purchases, sales of 534 tons of corn silage,[2/] and a rise in crop expenses of a little more than half-way to its maximum. Farm organization is stable except that the area of less well drained land in silage increases to support the sales.

Stage III links the change in land quality more closely to the dairy enterprise. With the mixed mainly legume-based ration available, the hay content drops to the new minimum, 33 percent, driving corn grain purchased down to its low. Hay is sold instead of corn silage. Crop expenses rise to their highest level. At this stage, the cost reduction in the dairy enterprise from the lower grain purchases is coupled with an increase in crop output both from the substitution of the mixed mainly legume for the grass and from the expansion of the corn silage area. The value of the crop surplus also rises as mixed mainly legume hay is sold rather than corn silage. These changes make this stage the main source of the benefit from tiling.

In the fourth stage,[3/] there is virtually no change in income or in any of the input or output factors. There is only a small rearrangement of crops, due to the new rotation restriction; some corn silage moves onto the better-drained land and is replaced on the poorer land by mixed mainly legume.

1/ Stage I is the analysis before tiling.

2/ Sales of any of the crops produced on the farms are allowed. Though normally corn silage would not be sold, the price specified makes it more profitable than the grass hay.

3/ This is the most profitable outcome after tiling discussed in the previous sections.

Table 12. Changes in Profitability and Enterprise Organization During the Transition from No Tile Drainage to Full Integration into the Farming System.

	BASE					CORN GRAIN ENTERPRISE				
	AI G(B),[a] 80 C, R(B)	AII G(A), 80 C, R(B)	AIII MML(A), 80 C, R(B)	AIV MML(A), 80 C, R(A)	Accum-ulated Change	BI G(B), 80 C, R(B),CG	BII G(A), 80 C, R(B),CG	BIII MML(A), 80 C, R(B),CG	BIV MML(A) 80 C, R(A),CG	Accum-ulated Change
Return Over Variable Expenses	21,285	28,445	42,119	42,124	20,839	21,521	30,081	42,194	42,508	20,987
Management Income	-31,403	**-31,085**	**-17,411**	**-17,406**	**13,997**	**-33,381**	**-31,463**	**-19,350**	**-19,236**	**14,145**
Change in MI from Previous Stage		**318**	13,674	5			**1,918**	12,113	114	
Accumulated Benefit from Tiling		7,160	20,834	20,839			8,760	20,873	20,987	
Enterprises										
Dairy: herd size	80	80	80	80	0	80	80	80	80	0
% hay in ration	67	67	33	33	-34	67	67	33	33	-34
Hay Crops, A: **Better drained land**[b]	25	25	25	17	-8	25	25	25	17	-8
Less well drained land	128	98	104	112	-16	94	94	94	63	-31
Corn Silage, A: **Better drained land**	25	25	25	33	8	0	0	16	0	0
Less well drained land	22	52	46	38	16	55	37	56	73	18
Corn Grain, A: **Better drained land**						25	25	9	33	8
Less well drained land						1	19	0	14	13
Crop Expenses, $	8,626	11,691	13,478	13,462	4,836	10,057	12,332	13,766	17,963	7,906
Feed Purchases										
Hay, T	58	0	0	0	-58	116	11	0	0	-116
Corn Grain, bu.	6,413	6,413	3,778	3,778	-2,635	4,642	2,935	3,034	0	-4,642
Soy Oil Meal, T	50	50	49	49	-1	50	50	49	49	-1
Feed Sales										
Hay, T	0	0	280	280	280	0	0	248	114	114
Corn Silage, T	0	534	0	0	0	0	0	0	0	0
Labor										
Annual, hrs.	6,734	6,851	6,890	6,890	156	6,682	6,735	6,863	6,761	79

[a] The abbreviations have the following meanings: G = grass hay crop, B = before tiling, C = cows, R = rotation A = after, MML = mixed-mainly-legume hay crop, CG = corn grain.

[b] Crop enterprises on the better and less well drained land are indicated by "I" and "II" respectively.

Table 13. Value of Additional Cow and Acre of Land During the Steps in Transition from No Tile to Full Integration of the Tile.

Stage		Value of One Additional[a]		
			Acre of Land	
		Cow	Better Drained	Less Well Drained
A I.	G(B), 80 cows, R(B)[b]	128	75	42
II.	G(A), 80 cows, R(B)	171	76	65
III.	MML(A), 80 cows, R(B)	266	108	95
IV.	MML(A), 80 cows, R(A)	266	108	95
B I.	G(B), 80 cows, R(B), CG	125	84	47
II.	G(A), 80 cows, R(B), CG	123	117	103
III.	MML(A), 80 cows, R(B), CG	259	117	103
IV.	MML(A), 80 cows, R(A), CG	270	108	95

[a] Value in terms of return over variable expenses.

[b] Abbreviations in footnote a of Table 12.

Figure 5a. Income, Input and Output and Farm Reorganization: The Base Analysis.

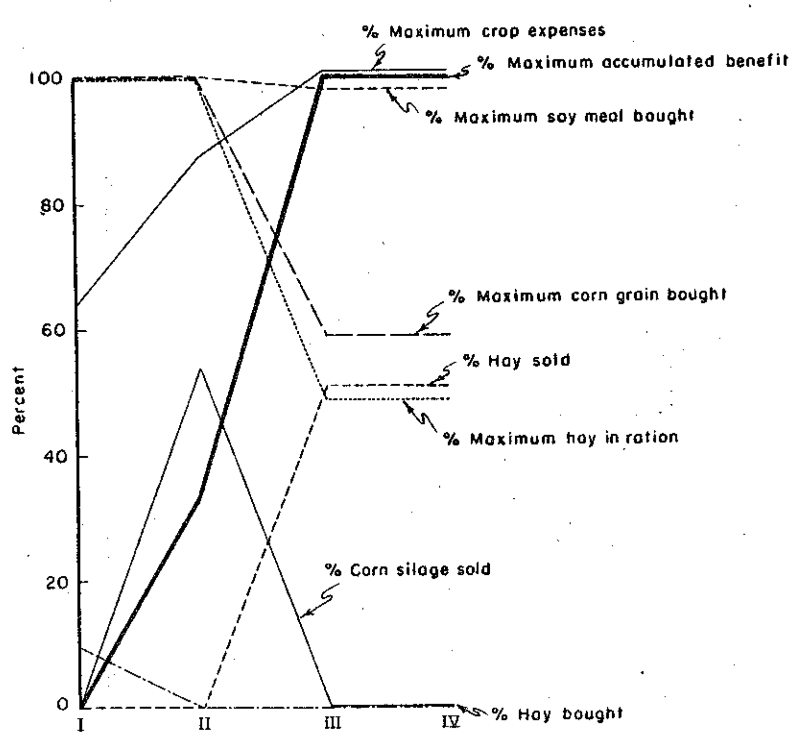
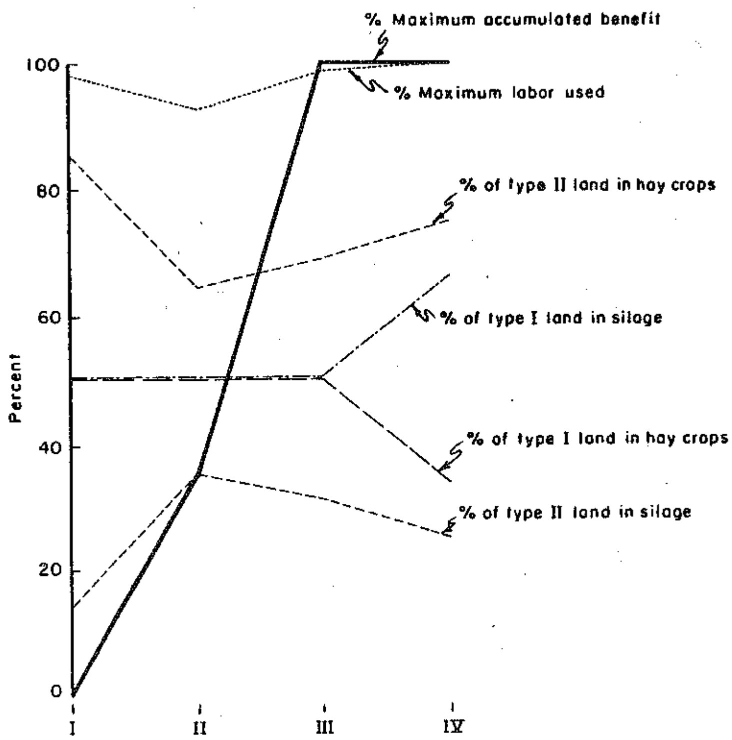


Figure 5b. Income, Enterprise Combinations and Farm Reorganization: The Base Analysis.



In sum, most of the benefit from tiling comes with the changes in hay crop and forage composition of the ration. At this stage, there is roughly a doubling in the value of surplus forage, \$15,400 vs. \$7,156; and a near halving of the cost of corn grain, \$10,541 vs. \$17,892. The second most valuable benefit is from the increase in yields. However, it is only \$318 more than the cost of having the farm tiled. The last benefit, the less restrictive rotation, is insignificant under this resource endowment. The rise in crop expenses, which supports all this, is about equally divided between the yield change, the change in hay type and the increased production of corn silage.

The Disaggregation of the Corn Grain Enterprise Analysis

Introducing a corn grain enterprise allows the farm to better utilize both the land in excess of forage needs and the corn producing capability of the farm. The distribution of the changes in income among the three posttiling stages shows that a greater portion comes in the second stage here than in the base, 42 vs. 34 percent, and a visible benefit is derived from the change in rotation restriction (Figure 6a).

Figure 6a. Income, Input and Output and Farm Reorganization: The Corn Grain Analysis.

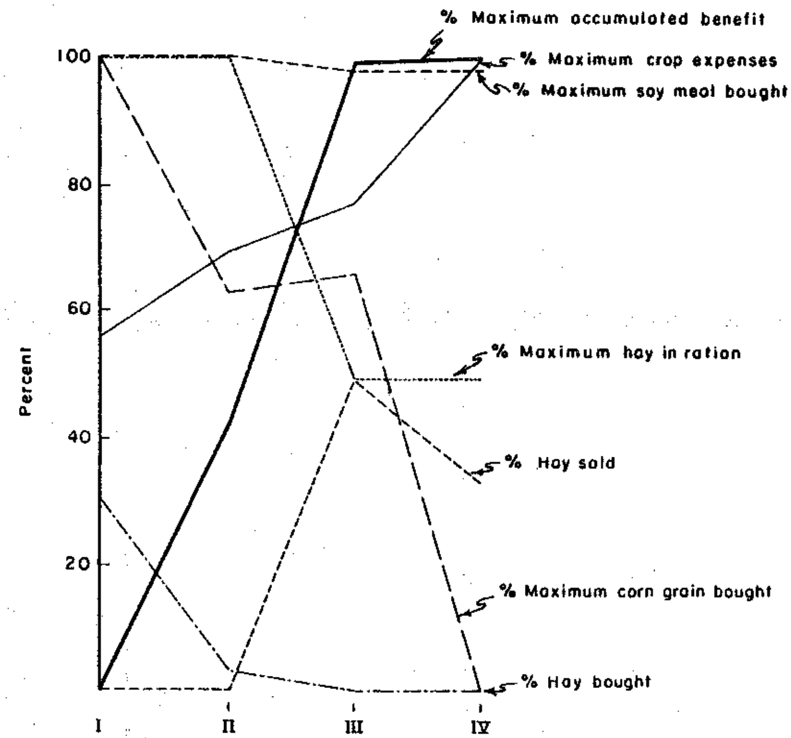
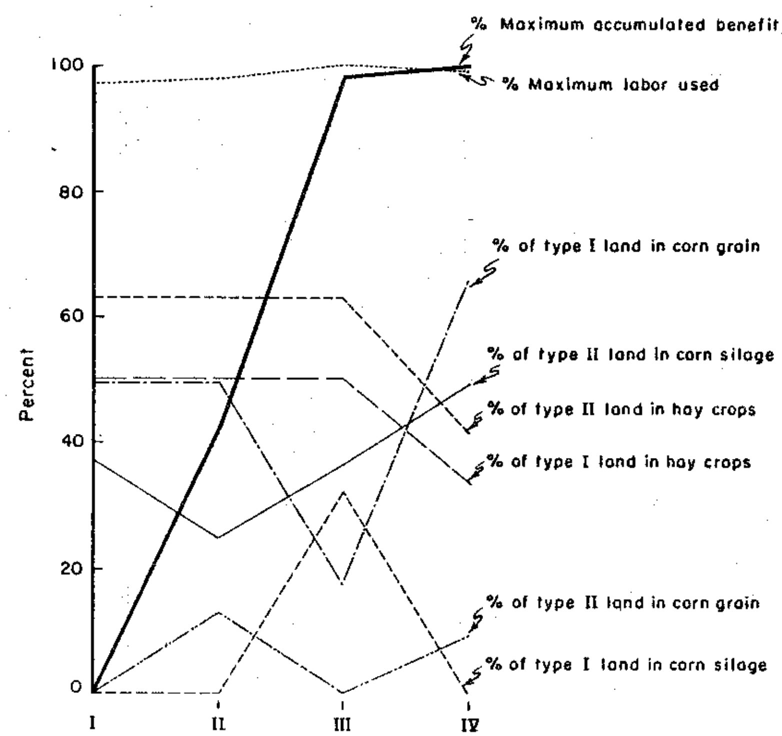


Figure 6b. Income, Enterprise Combinations and Farm Reorganization: The Corn Grain Analysis.



The technical adjustments and their values are modified from those in the base. In Stage II, the larger proportion of the total benefit is associated with a 37 percent decrease in corn grain purchased. However, total corn acreage is only 4 acres more than in Stage II of the base, where excess land produces corn silage for sale. Also in contrast with the base, a small amount of hay is purchased. The effect of the higher yields on the cropping pattern is to put some of the poorer land into corn grain instead of corn silage. The tiling costs are more than repaid, by $1,918.

Again, the largest part of the benefit comes in Stage III, where the feeding of corn grain is reduced, rather than just the purchases. The rotation restriction is binding and, in conjunction with the rise in corn silage content of the ration, forces land out of grain and into corn silage. Hay production is up again, because of the yield differential between mixed mainly legume and grass, but consumption is down, so hay selling expands to nearly half of the hay produced.

The last stage realizes a benefit of $114, but involves a major reorganization of the crops. With the less restrictive rotation, corn grain expands, reducing corn grain purchases to zero and hay sold to a third of production. This is accompanied by the largest increase in crop expenses.

The difference in benefit structure between this sequence and the base sequence suggests that much more benefit comes from reducing the grain content of the ration than from producing it on the farm. Also, the relative values of producing corn silage and grain are indicated by the shift in land from grain to silage in Stage III. Corn silage is given priority over grain when the corn area is limited. That 57 percent of the total benefit from tiling is produced at this stage suggests that silage is much more profitable than grain. Nevertheless, the presence of more corn crops does increase the benefit derived from the change in yields.

Managing the Transition

The minimum adjustment, raising the levels of yields of existing crops (grass and corn silage), is barely sufficient in itself to pay for the tiling system assumed. Without the new optimal level of inputs and farm reorganization, the benefit would be even less. However, if more hay were purchased before tiling, the benefit from eliminating it would be greater. Finally, if the initial yield levels were lower, the yield increment would be greater. All these might make it profitable (but not optimal) to just accept the yield increase and go no further.

Implementing the change in hay crop and ration as quickly as possible is important. Either makes the tiling investment significantly profitable. Essentially, the full benefit appears when both of these changes have been accomplished. The rearrangement of crop enterprises which follows the change in rotation restriction is insignificant, unless land area has been a major limiting factor on the farm. At the yield increase stage, growing corn grain is a possible means of capturing a larger part of the benefit from tiling if other adjustments are prohibited or made difficult.

The largest single benefit comes from the reduction of corn grain fed, which occurs when the higher energy hay is used and the corn silage content of the ration is raised. This change is also accompanied by the appearance of a forage surplus, which is sold as hay. Raising the corn silage content of the ration should be an early goal after tiling. The change to mixed mainly legume hay crops is probably of similar benefit. However, it may be one of the more difficult changes to make. Revision of the crop rotation is likely the easiest change to make, in that it requires no other adjustments in the kinds of operations performed. However, it does seem to be a very small source of benefit.

A tentative order of adjustments is to:

1. raise yields,
2. change rotation limits,
3. expand corn silage acreage and content in ration,
4. expand corn grain (if grain is already being grown), and
5. introduce the mixed mainly legume hay crop.

With the time value of money, it is, of course, worthwhile to get through the sequence as quickly as possible. Delays in completing the adjustments reduce the net present value of the stream of benefits. Cash flow and the time needed to acquire new management skills necessary may inhibit the transition. The delays will become crucial when the farm has not yet entered some second stage of adjustment. Any two of the three major adjustments will produce a substantial positive net return to tiling, but no single one will by itself.

These results also carry some implications for the management of the other transition--the extent of coverage. In the intervening time while not all of the farm is tiled, it should not be assumed that the tiled land can be farmed in just the same manner as the rest. The yield increment may not pay for the tile. As with the whole farm, it is important to move along the sequence of technical adjustments as quickly as possible. With partial coverage of the farm, a value of pushing the changes in management of the smaller areas to their conclusion is the learning experience they provide the farmer. The skills involved can be acquired without having to apply them immediately to the whole farm.

Deciding to Tile

The decision to tile should be based on a comparison of the costs paid and benefits gained. These are site specific. They vary from farm to farm depending on the farm's characteristics and resources. Some generalizations can be made, however. Costs depend on the type of tile system used and its design specifications. These, in turn, are determined mostly by the physical properties of the land and by the local climate. Costs tend to rise as permeability and slope diminish, and as the amount of water to be removed and the stoniness of the soil increase.

The benefit value is most influenced by the initial drainage class. The poorer the drainage at the start, the bigger the improvement in yields and the larger the increase in income. Milk production level has a lesser effect and its greatest benefit comes at the midlevel, 13,000 pounds per cow. At high production, forage is a smaller part of the ration and so more of the increased production is sold, rather than fed. At low production the advantage of a higher nutrient content in the forage is not as great because of the lower nutrient requirements.

The addition of a corn grain enterprise is of small value, generally not enough to pay the costs of having it. Nevertheless, tiling does create the capacity to produce all or most of the corn grain required.

There is strong support for two of the major adjustments in farm operations. More corn silage is grown in every situation, the area almost doubling. The switch to a legume-based forage is an important and universal source of benefit.

Underlying these major adjustments are other technical and administrative adjustments which must be included to complete the adaptation of the farm to the improved drainage. Some are explicit in the study and some are implicit. Total operating costs drop, but are redistributed through the year and into different enterprises. With lower feed and grain purchases, livestock expenses drop by somewhat less than half. Crop expenses increase by nearly a half, mostly because of larger fertilizer and machinery expenses. The decrease in the livestock expenses exceeds the increase among the crops. The livestock expenses are spread out through the year and are "rolled over" as the milk checks come in. On the other hand, crop expenses are paid mostly in the spring, and accumulate at least until harvest. If the crops are fed rather than sold, recovery of costs is even further delayed.

The change in labor use depends mostly on whether or not the herd is expanded. If not, labor increases by only a few percent, but is redistributed out of the summer and into the fall. If the herd size is raised, labor rises almost proportionately, as well as being redistributed so that the peak is in the fall. Lastly, if the farm begins to produce a marketable surplus of forage, arrangements must be made to sell it. Further administrative integration could be brought to the surface by taking the enterprise combinations to the budgets and determining the amounts of inputs used before and after tiling.

Overall, the 80-cow farm is quite able to adapt itself, responding to the new opportunities presented and profitably integrating the better drained land into its operations.

THE ECONOMIC IMPACTS OF INSTALLING TILE DRAINAGE ON THE STANCHION BARN HOUSING FARMING SYSTEM

Three important characteristics differentiate this stanchion barn housing system representative farm from the freestall system representative farm analyzed previously (Table 1). First the dairy cow housing/milking system is a stanchion barn with a maximum capacity of 60 cows. Second the crop land consists of 100 tillable acres and 75 acres of pasture. Third, the forage consists exclusively of dry hay. The same two hay crops, grass and mixed mainly legume, are grown before and after tiling. The input and output prices (Table 5) and per acre tiling costs (Table 4) are the same as in the freestall housing representative farm analysis; dairy housing and feeding systems have lower per cow investment costs.[1]

The Response to Tiling

The limited land area and the dry hay ration combine to make the herd size change with tiling, rather than stay constant at the 60-cow limit. Because the hay crop harvested as dry hay has lower harvested nutrient yields per acre than when harvested as hay crop silage, the number of cows an acre can support is less. At the prices used, buying hay to feed to cows is not profitable, except at the high milk production level. Consequently, return over variable expense is maximized by limiting the herd sizes to the number of cows which the farm can supply with forage, except in the high milk production situation.

Most Profitable Combinations of Enterprises

Because of the limited options available (only one crop and one ration allowed) the reorganization of the 60-cow farm follows a relatively simple pattern. In this section the base situation is described first, setting the pattern followed by all but one of the other situations analyzed. That one, which is the one for high milk production, is described in some detail because of the information it provides and because it most readily compares with the analyses of the freestall housing representative farm.

Tiling the base farm results in an increase in management income of $5,900 (Table 14). The increase in income, however, is much smaller than in the representative farm analyzed earlier.

All the land, 25 acres of better drained and 75 acres of less well drained, is planted to hay crop. Because forage production is the limiting factor determining the herd size, all forage is fed and any increase in production is used to increase herd size. As a result of the investment in tile the herd size which the farm can support rises from 25 to 40. Labor use increases by nearly half. With the higher nutrient quality of the legume hay, purchases of soybean oil meal drop by two-thirds while corn grain increases by only about a tenth, despite the much larger herd size.

Only at the high milk production level (16,000 pounds per cow) is the stanchion barn filled to capacity, 60 cows. The change in management income is $6,675 or about $111/cow. This compares with the $168/cow change with high milk production in the previous analysis. The $57 difference is largely a result of differences in ability to respond to tiling.

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[1] Buildings, machinery complements, and detailed enterprise budgets are available from the authors. The crop enterprise budget information used in the analyses is summarized in Appendix Table 5. The least cost balanced rations and livestock enterprise budgets are summarized in Appendix Tables 6 and 7.

Table 14. Changes in Profitability and Enterprise Organization Resulting from the Investment in Tiling on the Stanchion Barn Housing System Representative Farms.

	Base			Low Milk Production			High Milk Production		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-24,848	-18,948	5,900	-28,204	-25,471	2,733	-17,624	-10,949	6,675
Internal Rate of Return			16.8			10.9			18.0
Enterprises:									
Dairy: Size	25	40	15	23	39	16	60	60	0
Hay, A: I [a/]	25	25	0	25	25	0	25	25	0
II	75	75	0	75	75	0	75	75	0
Corn Grain, A: I									
Feed Purchases:									
Hay, T							271	151	-120
Corn Grain, bu.	1,721	1,847	126	1,031	760	-271	5,634	4,396	-1,238
Soy Oil Meal, T.	9	3	-6	4	1	-3	36	14	-22
Annual Labor, Hrs.	2,992	4,434	1,442	2,720	4,049	1,329	6,372	6,567	195

[a/] Crop enterprises on the better and less well drained land are indicated by "I" and "II" respectively.

Table 14. (Continued)

	Poorer Drainage			Better Drainage			Grass After Tiling		
	Before	After	Change	Before	After	Change	Before	After	Change
Management Income	-27,791	-20,858	6,933	-22,591	-17,513	5,078	-24,848	-23,989	859
Internal Rate of Return			18.6			15.1			7.2
<u>Enterprises</u>:									
Dairy, Size	16	36	20	31	43	12	25	37	12
Hay, A: I	25	25	0	100	100	0	25	25	0
II	75	75	0				75	75	0
<u>Feed Purchases</u>:									
Corn Grain, bu.	1,095	1,652	557	2,190	1,993	-197	1,721	2,562	841
Soy Oil Meal, T.	6	2	-4	12	3	-9	9	14	5
Annual Income, Hrs.	2,082	4,077	1,995	3,660	4,711	1,051	2,992	4,141	1,149

In the earlier analysis, the representative farm can alter the forage composition to include more corn silage, which means that concentrate purchases are reduced.

The effects of the mixed mainly legume hay crop show up in the feed purchases required in this analysis with high milk production. The quantity grown increases and reduces purchases of hay from 271 to 151 tons, despite increased hay consumption per cow. The higher energy and protein contents of the mixed mainly legume mean that forages are providing more nutrients thus diminishing the need for concentrates. Corn grain purchases drop about a quarter and soy purchases almost two-thirds, illustrating the advantage of mixed mainly legume over grass when corn silage is not included in the roughage.

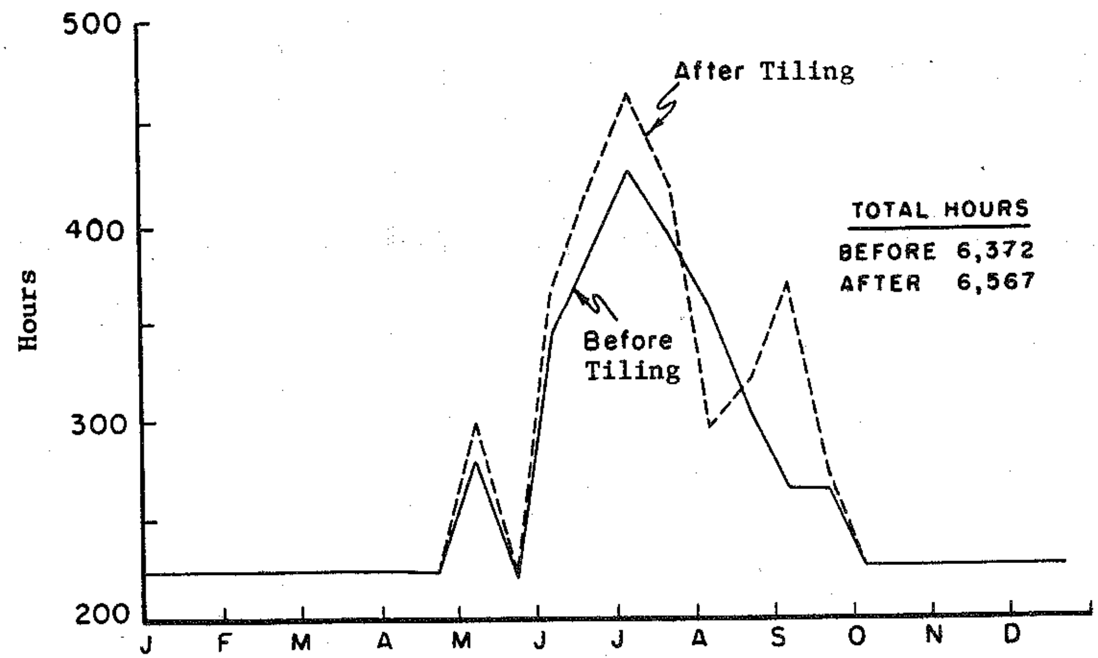
The analysis with a high milk production level demonstrates the labor distribution of the hay-based system (Figure 7). Before tiling there is a small peak in the spring during planting, followed by a broad summer peak which is centered on the first half of July. The single-harvest nature of the grass hay produces the single peak. After installing the tile and switching to mixed mainly legume hay, two harvests are assumed, splitting the harvest peak into two parts, the larger still in July and the smaller in early September. Again there is a 3 percent change with tiling.

Milk production and initial drainage status sensitivity analyses are presented in Table 14. As milk production level varies, the changes in income progress from low production, with the smallest change, to high production. This results from the advantage of the mixed mainly legume hay over grass and from the change in herd size. Nutrient requirements of the cows decrease as production decreases, while their dry matter capacities is less affected. Thus, less concentrated feed sources are needed at low production, reducing the benefit of replacing the grass in the ration by mixed mainly legume. Changes in herd size, though, increase as production decreases. Feed purchases show an interaction between milk production and the change in herd size. At low production, purchases of both concentrates are reduced. In the base, the higher protein content of the hay is able to fill a larger proportion of the protein requirement of the herd, so soy purchases drop; the energy content, however, is not sufficiently higher and so grain purchases increase. At high production the lack of a change in herd size allows the better forage to reduce all feed purchases.

Three analyses show the effect of initial drainage status on the size of the benefit from tiling. The benefit is greater when the initial drainage is poorer. The $1,855 range is much smaller than that of the counterpart situations discussed earlier. In this analysis, the ration is the same, regardless of initial drainage status, limiting the impact of drainage status to the size of the change in cost of forage production and to the size of the change in herd size.

Two other cropping patterns were examined--one with a corn grain enterprise and the other with grass hay after installing the tile.

Figure 7. Monthly Labor Distribution Before and After the Enterprise Reorganization Resulting from Tiling the 100 Tillable Acres on the Stanchion Barn Housing System Representative Farm with High Milk Production.



The corn grain enterprise was considered only on the better drained land. Corn grain cannot compete with mixed mainly legume hay production as long as the land resource cannot meet the roughage requirements of the herd. The result with grass after tiling, which gives an indication of the shares of the benefit from tiling which can be attributed to the higher yields and to the new hay crop, is a small positive change in management income. As in the larger representative farm, the change in yield by itself is barely enough to pay for the tiling. Twelve of the fifteen additional cows are added with this adjustment, indicating that most of the rise in the potential herd size occurs with the yield change and little with the change in hay crop. With no improvement in nutrient quality of the hay, purchases of both concentrates rise with the herd size while with mixed mainly legume, they both decline.

Implications of Tiling

Tiling this representative farm is of much more marginal benefit than tiling the larger, more flexible representative farm. The largest part of the benefit accompanies the change in hay crop, while the higher yields are of secondary benefit. The largest source of benefit is thus the reduction in purchased grain. Lower per-ton costs of hay contribute a smaller part of the benefit. The inflexibility of this farming system, in terms of the number of options available in enterprise selection, reduces its ability to respond to the tiling. Comparing the two farm situations with high milk production, the increase in management income is $11 per cow in the smaller farm and $144 per cow for the larger.

SUMMARY AND CONCLUSIONS

In large areas of Northern New York, poor drainage limits the productivity of agriculture and has multiple effects on dairy farms which predominate in the area. Yields of crops are both reduced and more variable because of poorer growth and less timely field operations; machinery operating and maintenance costs are higher; and profitable crops which are sensitive to drainage cannot be grown. Installation of a subsurface drainage system, tiling, is a potential solution which needs to be examined in the specific context of the Northern New York dairy farm; this is the purpose of this study. To achieve this, the following objectives were set:

1. to construct enterprise budgets for the predominant Northern New York dairy farming systems,
2. To determine the most profitable enterprise organization both before and after tiling,
3. To determine the value of tiling with full and partial adjustment of the farm to the improved drainage, and
4. To evaluate different strategies of tiling and reorganizing the farm.

Methodology and Procedures

This is a study of technological change. It takes as basic the premise that the change cannot be properly evaluated except in the context of the system in which it will operate. Tiling costs were calculated for installation and on an annual basis. The changes occurring in the various enterprises were specified. In particular, crop yields were raised, input levels adjusted, hay crops changed and livestock rations reformulated. All of these were incorporated in the enterprise budgets, from which the technical coefficients used in the analysis were derived. That is, the effect of tiling was portrayed in a linear programming model by changing the input-output relationships used.

Two synthetic farms represented the common types found in Northern New York. The first one, had 200 crop acres, 75 acres of pasture, an 80-cow freestall barn and a ration based on a mixture of hay crop and corn silage. The second had 100 acres of crops, 75 acres of pasture, a 60-cow stanchion barn and a ration with dry hay as the only forage source. Four crop enterprises were considered--grass and mixed mainly legume hay crops, corn silage and corn grain. The grass was assumed to be used before tiling and the mixed mainly legume afterwards. Crop budgets covered a range of yields, representing different land qualities and drainage classes.

Livestock budgets varied in two dimensions--the proportions of hay crop to corn silage and the level of milk production. The methodology used in budgeting was the economic engineering approach with economic surveys from Northern New York and agronomic and animal husbandry recommendations as sources of data.

The linear programming model was solved twice, using different sets of technical coefficients, one for before and one after tiling. Aside from the changes in yield, hay crop and ration already portrayed within the enterprise budgets, one result of tiling was incorporated at the whole-farm level; the amount of corn allowed in the rotation was raised.

Summary of Results

Installation of the tile, with a trencher and using plastic tubing, costs $556 per acre or $111,210 for the freestall housing system representative farm. For the smaller situation, the total cost was half of this amount. The annual cost, spreading the installation cost over the life of the investment and adding charges for maintenance and repair, was $34 per acre and came to $6,842 for the 200 acres or $3,421 for the 100 acres.

The freestall housing/200 tillable acre base farm, representing a typical Northern New York dairy farm, had 150 acres of somewhat poorly drained and 50 acres of moderately well-drained cropland. The average production level of the herd was 13,000 pounds per year. Before tiling, the hay crop in the forage mix was grass and afterwards it was mixed mainly legume. Management income rose $13,997 with tiling. The internal rate of return on this investment in tiling is about 19 percent. The primary changes in farm organization were a doubling of the corn silage acreage and a redistribution of crop labor away from the midsummer and into the fall. In dollar terms, the major sources of benefit were decreases in hay and corn grain bought and an increase in hay sold. These were partially offset by an increase in crop expenses.

Sensitivity analyses tested the effects of different resource bases and management strategies. The added productivity of the land could be utilized in the production of corn grain or in expansion of the herd. With the assumed price relationships, neither was profitable. However, tiling did make it technically feasible to produce all the corn grain used on the farm or to grow roughage for almost double the herd size. Milk production levels of 10,000 and 16,000 pounds per year had little influence on the value of tiling. The initial drainage status of the farm exerted the most significant influence on the value of tiling. In the situation starting with poorly and somewhat poorly drained land, tiling raised the management income by $19,161 while only $11,519 when the farm was moderately well drained before tiling. When changes in yield and milk production and the addition of a corn grain enterprise were combined, the effects were roughly additive. The corn grain enterprise came closest to being economically viable with high milk production.

Some of the intermediate stages between the initial and final states were shown in a disaggregation of the process of technical adaptation. Three adjustments in operations of the farm were made sequentially: (1) the yields were raised, (2) the mixed mainly legume hay crop was introduced, and (3) the restriction on the amount of corn in the rotation was relaxed. At each stage the most profitable crop enterprises and forage mix were determined. The dollar value of the benefits received from tiling was roughly equally split among the changes in yield and hay crop and the increase in corn silage content in the ration. The change in allowable rotation had a relatively insignificant effect. Including a corn grain enterprise allowed the increase in yield to capture more of the benefit from tiling.

Shadow prices of cows and land also provided a measure of the value of tiling by showing the effect of tiling on the value of an additional head or acre. In the base, the shadow price of a cow rose by $138, from $128 before installation to $266 afterwards. The change was less at low milk production, $120, and at high milk production, $131. The initial drainage status of the land had a stronger influence. With poorer drainage, the shadow price rose by $161, while only $91 in the situation with better drainage. The changes in the value of an additional acre of land were determined by the use to which the land would be put. In the base, where more land would produce hay to sell, the shadow price rose by $33. When land was used to feed cows to produce milk, as in the Variable Herd Size situation, the value went up by $170. In comparison, the cost associated with moving from the before to the after tiling states was $34 per acre.

<u>The smaller representative farm with a stanchion barn</u>, dry hay forage base, and 100 acres of cropland of the same drainage classes as in the 80-cow farm showed generally the same responses to tiling. There were three noteworthy exceptions. Forage purchasing was not profitable except at high milk production, so the herd size was determined by the farm's production capacity. This was not sufficient for 60 cows, but changed with tiling, leading to expansion of the herd. The returns to tiling were smaller than when hay crop and corn silage made up the ration. However, the returns were large enough to more than pay for the tiling, showing that the ability to grow and use more corn silage was not a requisite for a positive net benefit from tiling.

Conclusions

Profitability

1. Drainage improvement has substantial (100-300 percent) net return on investment in most situations,

2. Optimal reorganization of the farm and adjustment of the farm's operations, i.e., integration of the tile into the farming system, are important to capturing the benefit from tiling,

3. As defined in this study, the farming system using a silage mixture derives a larger benefit from tiling than the farm using only dry hay, and

4. The relative profitability of tiling is much affected by the initial drainage class of the cropland, but not much by the production level of the herd.

Source of Benefit

1. Among the technical changes in the farming system, the total benefit from tiling is about equally split among the changes in yield, hay crop and corn silage content of the ration, and
2. In terms of the changes in cash expenses and income of the firm, before including the cost of tiling, more than two-thirds comes from the switch from forage deficit to forage surplus and most of the remainder from the change in the nutrient quality of the forage base.

Farm Firm Reorganization

1. Partial adaptation to the tiling reduces the benefits substantially,
2. Increasing the size of the herd is not a necessary prerequisite to receiving a positive net return to tiling,
3. The area of corn silage nearly doubles if the herd size is held constant and triples if the herd is expanded to use up all the added forage production capacity,
4. Crop expenses increase by more than half while livestock feed costs drop by about a third,
5. Feed purchases decrease and/or sales of excess appear,
6. Total labor use increases slightly, but undergoes considerable redistribution, primarily from the mid-summer into the fall,
7. Tiling makes production of essentially all the corn grain fed to the livestock technically feasible, though the price assumptions used make this economically unprofitable, and
8. Tiling nearly doubles the number of cows that can be supported by on-farm forage production.

Implications for Further Research

The study has brought into focus several new issues and laid a foundation for examining some old ones not previously open to study. The methodology appears to function effectively. It can be used as a decision aid by farmers and extension agents.

With additional development, the model can be used to further examine the impact of tiling on milk production brought about by the higher nutrient qualities of crops. The effect of keeping the grass hay crop and increasing the corn silage content of the ration should be examined using a one-third grass, two-thirds corn silage ration. This will tell whether this strategy of utilizing the improved drainage will yield an increased net return to tiling.

The issues of transition from an untiled to a tiled farm can be explored further. Since corn silage seems to add to the ability of the farm to take advantage of the tile, the conversion from a dry hay to a hay crop-corn silage feeding system should be explored. Also, the extent and location of the tile can be varied to determine where the breakeven points are for various technical adjustments and to determine which land to tile first.

Having considered the microlevel case, higher levels of aggregation should be given some attention. The economics of drainage districts and the role of the public sector in them are relatively unexplored areas. Projection of the regional impact of tiling would be complementary. For example, an input-output model could show the effects of changes in farm operations, purchases and sales of feeds and forages, credit and labor use, and the construction industry.

Though tiling is an expensive investment, it does have substantial net returns if the farmer makes the proper adjustments to take full advantage of the opportunities presented by improved drainage of the land.

APPENDIX

Appendix Table 1. Crop Yields, Selected Variable Expenses, Labor Requirements and Fixed Expenses by Drainage Classes: Hay Crop, Corn Silage and Corn Grain.

	Drainage Class	Yield	Selected Variable Expenses	Labor Requirement	Fixed Expenses
			($)	(hrs./A)	($/A)
		(T. HEq)			
Grass-hay crop silage	WD	3.6	48.00	8.2	106.02
	MW-WD	3.3	45.00	8.1	105.15
	MWD	2.9	42.00	7.9	104.01
	SPD	2.1	33.00	7.4	101.69
	PD	1.2	29.00	6.7	99.03
		(T. HEq)			
Mixed mainly legume-hay crop silage	WD	4.6	65.00	8.5	106.02
	MW-WD	4.2	60.00	8.4	105.15
	MWD	3.7	55.00	8.2	104.01
	SPD	2.9	48.00	7.9	101.69
	PD	1.9	38.00	7.2	99.03
		(T. HEq)[a/]			
Corn silage	WD	5.4	81.00	8.5	110.62
	MW-WD	5.0	78.00	8.4	109.30
	MWD	4.5	76.00	8.3	107.61
	SPD	3.7	66.00	8.0	104.92
	PD	0.0	--	--	--
		(bu. dry Eq)[b/]			
Corn grain	WD	90	93.00	5.8	159.72
	MW-WD	83	89.00	5.7	157.84
	MWD	75	88.00	5.6	155.07
	SPD	55	75.00	5.4	146.33
	PD	0	--	--	--

[a/] Corn silage yields convert to as-fed weights by multiplying by 3 T, CS/T, HEq.

[b/] Corn grain yields convert to high-moisture ear corn by multiplying by 0.0414 T, HMEC/bu., dry CG equivalent.

Appendix Table 2. Least Cost Balanced Dairy Cow Rations with Hay Crop Silage and Corn Silage Forage Bases, Annual Consumption Per Cow.

	Pounds of Production Per Cow		
	10,000	13,000	16,000
All Mixed Mainly Legume Hay Crop Silage			
Hay Crop Silage,[a] T. HEq	5.2[b]	4.9	4.6
Corn Silage, T.[c]	0	0	0
Dry Shelled Corn, Bu.	45	66	89
Soybean Oil Meal, Cwt.	1	3	7
2/3 Mixed Mainly Legume Hay Crop Silage and 1/3 Corn Silage			
Hay Crop Silage, T. HEq	3.4	3.2	3.0
Corn Silage, T.	5.1	4.8	4.5
Corn Grain, Bu.	34	55	76
Soybean Oil Meal, Cwt.	3	7	11
1/3 Mixed Mainly Legume Hay Crop Silage and 2/3 Corn Silage			
Hay Crop Silage, T. HEq	1.7	1.6	1.5
Corn Silage, T.	10.2	9.8	9.2
Corn Grain, Bu.	16	36	57
Soybean Oil Meal, Cwt.	8	11	15
All Grass Hay Crop Silage			
Hay Crop Silage, T. HEq	4.8	4.6	4.3
Corn Silage, T.	0	0	0
Dry Shelled Corn, Bu.	58	77	96
Soybean Oil Meal, Cwt.	5	9	13
2/3 Grass Hay Crop Silage and 1/3 Corn Silage			
Hay Crop Silage, T. HEq	3.6	3.4	3.2
Corn Silage, T.	5.3	5.0	4.7
Dry Shelled Corn, Bu.	40	60	79
Soybean Oil Meal, Cwt.	8	11	15

[a] 60 percent moisture.

[b] Quantities are amounts consumed for all figures.

[c] 70 percent moisture.

Appendix Table 3. Least Cost Balanced Dairy Heifer Rations with Hay Crop Silage and Corn Silage Forage Bases, Consumption from Birth to Freshening.

	Grass	Mixed Mainly Legume
All Hay Crop Silage		
Hay Crop Silage, T. HEq	3.3	3.6
Corn Silage, T.	0	0
Dry Shelled Corn, Bu.	66	47
Soybean Oil Meal, Cwt.	1	1
2/3 Hay Crop Silage and 1/3 Corn Silage		
Hay Crop Silage, T. HEq	2.5	2.5
Corn Silage, T.	3.4	3.3
Dry Shelled Corn, Bu.	55	42
Soybean Oil Meal, Cwt.	1	1
1/3 Hay Crop Silage and 2/3 Corn Silage		
Hay Crop Silage, T. HEq		1.3
Corn Silage, T.		6.8
Dry Shelled Corn, Bu.		32
Soybean Oil Meal, Cwt.		1

Appendix Table 4. Total Selected Variable Expenses, Labor Requirements, and Fixed Expenses for Dairy Cows and Heifers.

Milk Production Level (lbs./yr.)	Roughage Mixture	Total Selected Variable Expenses ($/yr.)	Roughage Mixture	Total Selected Variable Expenses ($/yr.)	Labor Requirement (hrs./yr.)	Fixed Expenses ($/head)
10,000	G(H)	203.48	MML(H)	215.32	50	306.70
	2G/1CS	208.58	2MML/1CS	211.45	50	306.70
			1MML/2CS	210.21	50	306.70
13,000	G(H)	232.15	MML(H)	235.67	57	311.45
	2G/1CS	236.83	2MML/1CS	240.18	57	311.45
			1MML/2CS	238.59	57	311.45
16,000	G(H)	263.77	MML(H)	267.36	66	316.20
	2G/1CS	268.65	2MML/1CS	271.62	66	316.20
			1MML/2CS	269.88	66	316.20
Heifers	G(H)	137.64	MML(H)	137.27	25	272.00
	2G/1CS	141.84	2MML/1CS	142.76	25	272.00
			1MML/2CS	143.23	25	272.00

Appendix Table 5. Drainage Classes and Crop Yields, Selected Variable Expenses, Labor Requirements and Fixed Costs for Stanchion Barn Housing System Representative Farm.

	Drainage Class	Yield	Selected Variable Expenses	Labor Requirement	Fixed Expenses
			($)	(hrs./A)	($/A)
		(T. HEq)			
Grass-Dry Hay	WD	3.5	54.00	12.0	124.46
	MW-WD	3.2	51.00	11.9	123.77
	MWD	2.8	47.00	11.4	122.85
	SPD	2.0	41.00	9.8	121.00
	PD	1.2	36.00	7.8	119.12
Mixed Mainly Legume-Dry Hay		(T. HEq)			
	WD	4.1	70.00	12.3	124.46
	MW-WD	3.7	66.00	12.1	123.77
	MWD	3.3	62.00	11.9	122.85
	SPD	2.5	54.00	10.9	121.00
	PD	1.6	44.00	8.8	119.12
		(bu. dry/Eq)[a]			
Corn Grain	WD	90	93.00	5.8	159.72
	MW-WD	83	89.00	5.7	157.84
	MWD	75	88.00	5.6	155.07
	SPD	55	75.00	5.4	146.33
	PD	0			

[a] Corn grain yields convert to high moisture ear corn by multiplying by 0.0414 T, HMEC/bu., dry CG equivalent.

Appendix Table 6. Least Cost Balanced Dairy Rations Utilizing Grass and Mixed Mainly Legume Hay.

	Pounds of Milk Per Cow			
	10,000	13,000	16,000	18,000
Grass Hay[a/]				
Hay, T. HEq	4.8[c/]	4.6	4.3	
Dry Shelled Corn, bu.	58	77	96	
Soybean Oil Meal, cwt.	5	9	13	
Mixed Mainly Legume Hay[b/]				
Hay, T. HEq	5.2	4.9	4.6	4.5
Dry Shelled Corn, bu.	45	66	89	101
Soybean Oil Meal, cwt.	1	3	7	10

	Heifers	
	Grass[a/]	Mixed Mainly Legume[b/]
All Hay Crop Silage		
Hay, T. HEq	3.3	3.6
Dry Shelled Corn, bu.	66	47
Soybean Oil Meal, cwt.	1	1

[a/] Rations in Region 3 of NEWPLAN data file.

[b/] Rations in Region 4 of NEWPLAN data file.

[c/] Quantities are amounts consumed. No harvest or feeding losses are included.

Appendix Table 7. Total Selected Variable Expenses, Labor Requirements and Fixed Expenses for Dairy Cows and Heifers for Stanchion Housing System Representative Farm.

Milk Production Level (lbs./yr.)	Roughage Mixture	Total Selected Variable Expenses ($/yr.)	Roughage Mixture	Total Selected Variable Expenses ($/yr.)	Labor Require-ment (hrs./yr.)	Fixed Expenses ($/head)
10,000	G(DH)	194.86	MML(DH)	203.64	65	262.05
13,000	G(DH)	223.90	MML(DH)	230.14	72	266.80
16,000	G(DH)	255.86	MML(DH)	261.09	81	271.49
Heifers	G(DH)	118.53	MML(DH)	119.10	25	196.44

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