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Farm Level and Regional Impacts of Forage Based Manure Management in Manitoba

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Introduction

At least as early as 2001 (Petkau and May, 2001), researchers began studying an emerging strategy for beef and hog farms in Manitoba. Farmers had begun to use more forage land for hog manure disposal. It had long been known that the productivity of forage land could be improved through the application of nutrients. Prior to the expansion of the hog sector in Manitoba (MB), the more common method of doing this was through the use of commercial fertilizers. The expansion in the Manitoba hog sector, starting in the 1980s, created more opportunities to improve productivity through the application of hog manure. This manure was often available at no cost to the forage producer.

The production basis for this study was a pilot site near La Broquerie, MB which now has three years of data on forage responses to manure application (see Ominski et al., 2008). Based on these production effects, farm level economic impacts of applying hog manure to forage production are assessed. This study also looks at regional impacts of changing manure management practices using an input-output model of the Manitoba economy. Input-output models track the impact of changes in one sector on all the sectors in an economy.

The La Broquerie Project

As the practice of forage based manure management became more common, researchers began to be concerned with the information available on the advantages and/or disadvantages of this practice in terms of environmental sustainability. There were apprehensions about methane and nitrous oxide production, the soil nutrient profile and the potential persistence and transmission of bacteria from the manure to the forage and to the cattle. These concerns, in relation to the productivity of the pasture and the animal, required additional exploration. To address this need, a team led by the University of Manitoba, along with numerous government and industry partners, was established using a research site in the RM of La Broquerie in Southeast Manitoba (SE20-5-8E). This site was selected as it was deemed environmentally sensitive – located in an RM with high animal density and it had forages that had not recently received manure nutrients.

In order to examine the impact of manure application, forage and animal productivity, greenhouse gas production, as well as nutrient movement and pathogen flow, the site contained six replicated paddocks:

- rotationally grazed only (no manure);
- harvested only (no manure);
- fertilized with an early summer application of hog manure and rotationally grazed;
- fertilized with an early summer application of manure and harvested;
- manure application divided between spring and fall application of hog manure and rotationally grazed; and
- manure application divided between spring and fall application of manure and harvested.

With three years of data analyzed, the University of Manitoba research team published a major report (Ominski et al., 2008) and several journal articles based on that data (for example Holley et al., 2008 and Undi et al., 2008). Production impacts from the La Broquerie project, which are relevant to the current economic analysis, are reported in a subsequent section of this report. In general, significant yield advantages were identified, nitrogen balances appeared sustainable and no evidence of pathogen transmission between hog manure and grazing cattle was found. There was evidence of phosphorus build up in some systems which lend some support to some of the phosphorus based regulation options being discussed in Manitoba.

Previous Economic Studies

An earlier study by Kelwin Management Consulting (2005) for the Stuartburn Piney Agricultural Development Association (SPADA) examined budgets for integrated operations of hog production and beef backgrounding operations in Southeast Manitoba. While this report contained details of soil and manure chemistry and went through the budgeting process in great detail, the yield effects of the manure on forages were never explained in detail or justified by trials. Thus the La Broquerie site has provided some very useful production trial information for forage and beef yields as well as environmental and epidemiological information.

The Kelwin team found that crop budgets in Stuartburn area were showing losses even with free manure available. They also found that integrated beef grazing and hog operations were more profitable than hog barns on their own. Using their 2003 prices, finish hog operations were losing nearly $10 per pig sold, but operations incorporating background cattle, with enhanced forages, were earning $41 per pig sold. With 2004 prices, the hog losses were closer to $5 while integrated operations were earning $54 per pig.

SPADA also supported a study of the regional impacts of the entire hog sector for the Rural Municipality of Stuartburn (Kelley Associates, 2003). Although this study did not use the formal input-output used in this study, very detailed calculations of tax revenues and input purchases were tabulated. Multipliers were applied to the expanding hog sector to consider regional impacts in other sectors, but a complete input-output model developed in this study was not used. Kelly Associates (2003) found that 12 new operations in the Stuartburn area would increase employment in Manitoba by 460 to 600 jobs and increase GDP by $16 to $21 million.

Production Impacts from La Broquerie

The manure management systems and forage and grazing yields utilized in the current economic analysis were as defined in the La Broquerie project (Ominski et al., 2008). Over three years, manure was applied to the six paddocks at the La Broquerie as detailed in Table 1. The average application to the forage was nearly 20 thousand liters of manure resulting in an average available nitrogen (N) application rate of 123.7 lbs per acre and an average phosphorus (P) application rate of 39.4 lbs per acre.

Table 1: Treatments and Yield Impact Details from University of Manitoba Site.

Liquid Manure Applied Liters/ac	19,695
Estimated Available N applied (lbs. N / acre)	123.7
P applied (lbs. P / acre)	39.4
Yield From Hayed Operation tnne/ acre	
Control (no Manure)	0.45
Full Application of Manure	1.70
Live Weight Gain from Grazing lbs./acre	
Control (no Manure)	89.1
Full Application of Manure	301.9

Of greatest concern to our study was the acreage need for manure application and the yield effects to that acreage in terms of hay production or weight gain in cattle. The La Broquerie Site trials suggested that forage yields could increase by as much as 278% and live weight gain could increase by 239%. These increases were incorporated into our budgets below and provide some rationalization for the budgets utilized in the SPADA study.

Two comments should be made regarding the assumed application rates. First, the La Broquerie site had targeted N application levels at 110 lbs/acre based on Manitoba Agriculture, Food and Rural Initiatives (MAFRI) removal rates, but the average rate applied was higher than that. Still, soil tests at the site show no evidence of N build up in the soils (at shallow and deep levels). So the application rate used did not add to soil N accumulation.[1]

A second comment regards the source of the manure and the nature of manure in commercial settings. Actual levels of dry matter, N and P vary a great deal in commercial lagoons. Total liters of manure would not be a good way to calibrate manure application in a regional study. In this paper we use the N output of all animals in the hog supply chain, from farrow to finish, to set N application levels similar to the La Broquerie trials. We ignored other nutrient balances and factors like moisture levels. This was a limiting assumption but was necessary to make the study tractable. Of special concern was the balance of P in the soil, if P was the nutrient we tracked and was the targeted application variable, acreages need and yield effects on the forages would have changed significantly. It may be important to let the farm community adapt to P based regulation before attempting a new study based on P application rates. Mitigation

[1] The analysis of N removed in the hay and from animals taken off the grazing pastures suggests real removal rates are closer to 60 lbs per acre. With 120 lbs applied versus this removal rate, and low soil and water table measures of N, the only remaining removal process, volatilization, must have been occurring at a significant level.

strategies for P build up, like the use of phytase in feed rations, to reduce P excreted and the growing use of multiple cells in lagoons to facilitate concentration of nutrients, would make this a very difficult balance to forecast.

Farm Level Impacts

To assess the impact of adopting this type of farming system, we looked at a typical farrow to finish hog operation and analyzed the impacts of adding a hay or pasture operation to that hog operation using manure from the hog operation to fertilize the forage lands. Manure application rates for these operations were assumed comparable to those at the La Broquerie site, as were improvements in hay or animal productivity.

Complete budgets, based on the most recent relevant MAFRI production costs estimates are attached in Appendix A. Most of the costs in these budgets were assumed to be 2008 levels. The exceptions were output prices for finished hogs, fed beef cattle, and hay; and input prices for purchased grain and feeder cattle. These prices were price averages based on the available data since 1997 as shown in Appendix B. For hay prices a historic correlation with feed grain was used to estimate the selling price.

The Base Case

The first major budget was a farrow to finish operation based on MAFRI's April 2008 budgets for a 500 sow farrow to finish operation (MAFRI, 2008a). We assumed a 500 sow operation with 10,216 pigs sold and all of the basic costs as assumed in that budget. In the feed rations we assumed feed was made on the farm and feed wheat, feed barley and canola meal prices were $125/tonne, $106/tonne and $184/tonne respectively. Finished hogs were sold at $159/kg. Manure was assumed to be given away for no payment with removal costs, as assumed by MAFRI, at $2.77 per finished hog sold.

The Hog and Forage Operation

In the second budget we began with the same hog operation as the base case but assumed the purchase of forage lands (already established) to match the manure spreading needs of the hog operation. We assumed the same application level (based on estimated available N) as the La Broquerie site. As such, 802 acres were required for the 10,209 feeder hogs and 60 acres for the sows, with a total required forage acreage of 862. The land was purchased at $400 per acre and some sharing of equipment between operations was assumed as per MAFRI's hay budget from March 2008 (MAFRI, 2008b). No establishment costs were included in the budgets. The assumed price of hay was $47 per tonne. The yield of hay from the La Broquerie trials with added manure was 1.7 tonnes per acre. If no manure was added, the forage yield was 0.45 tonnes per acre.

The Hog and Beef Operation

In the third budget we again started with the same hog operation as the base case but assumed the purchase of pasture lands (already established, but not fenced) to match the manure spreading needs of the hog operation. We assumed the same application level (based on estimated available N) as the La Broquerie site, a total acreage of 862. The land was again purchased at $400 per acre. Costs were based on the March 2008 MAFRI budgets for beef grassing costs (MAFRI, 2008c). The key assumptions for this budget were with regard to animal weights, stocking rates and buying and selling prices. The La Broquerie trials had live weight gain of 301.9 lbs per acre on calves brought in at an average weight of 590 lbs and taken off at an average of 850 lbs. Based on the average daily gains achieved in the La Broquerie study, it was estimated that the 862-acre land base could support1,001 calves. Calves were brought in at prices $0.15 per lb higher than they their selling price of $0.88 per lb.

Table 2 summarizes the results of these main cases as well as stand-alone forage and grazing operations. The indication is that synergies exist when hog and forage or beef operations are integrated. Beef and forage operations without manure-supplied nutrients, at 10 year average output prices, lost money. The 862 acre forage operation alone lost $33,808 and the beef operation lost $3,589. When integrated with the hog operation, however, they increased the profitability of the whole farm. A hog farm would see an increase of $1.10 in profits, to $50.31 per hog, by buying forage land, applying manure from the hog farm and haying it. That same base farm could increase profits by $4.73 to $53.94 per hog by buying similar land and using it for grassing beef calves.

Table 2: Returns from Various Operations used in this Study

	Just Hogs	Hogs and Hay	Just Hay	Hogs and Beef	Just Beef
Income					
Calf Sales				$748,792	$220,882
Hay sales		$69,450.12	$18,189		
Hog Sales	$1,624,314	$1,624,314		$1,624,314	
Total Income	$1,624,314	$1,693,764	$18,189	$2,373,105	$220,882
Total Operating Costs	$799,516	$831,488	$25,791	$1,478,031	$202,583
Labour Costs					
Hogs	$140,400	$140,400		$140,400	
Forage		$6,475	$6,475		
Beef				$3,018	$3,018
Total Labour Costs	$140,400	$146,875	$6,475	$143,418	$3,018
Fixed Costs					
Depreciation:					
Total Depreciation Cost	$126,756	$131,558	$4,801	$129,656	$2,900
Investment:					
Total Investment Cost	$54,948	$69,877	$14,930	$70,920	$15,972
Total Fixed Costs	$181,704	$201,435	$19,731	$200,576	$18,872
Total Expenses	$1,121,620	$1,179,798	$51,997	$1,822,024	$224,472
Net Income	**$502,693**	**$513,966**	**-$33,808**	**$551,081**	**-$3,590**
Net Income/hog	**$49.21**	**$50.31**		**$53.94**	

The key assumptions of these budgets are listed in Table 3. The yield assumptions come from production data from the La Broquerie site (see Ominiski et al. 2008) and the price assumptions are based on 10 year averages (see Appendix B).

Table 3: Key Price and Production Assumptions

Price of Hogs /ckg	**$159**
Forage Acres Bought	**862**
Price of Hay $/tnne	**$47**
Price of Feeders $/lb	**$1.03**
Price of Feds $/lb	**$0.88**
Hay Yield tnne /ac (manure)	**1.70**
Hay Yield tnne /ac (no manure)	**0.45**
Live Gain lbs/ac (manure)	**301.9**
Live Gain lbs/ac (no manure)	**89.1**

Phosphorus and Manure on Crop Land

While the information presented so far clearly supports integrated forage and hog operations as a win-win scenario for both operations, there are a few concerns arising from recent manure management regulations and the current high grain prices. Beginning in the fall of 2008, manure can be spread on land in Manitoba at N removal levels only until P soil levels reach a level of 60 parts per million (ppm) as measured using Olson's method (see MAFRI, 2008d). By the third year of the trials at La Broquerie, P levels had started to approach 60 ppm. At higher P levels in the soil, manure has to be applied at P removal rates. This type of application can favor some crops over forages because they remove more P as a percentage of their yield than forages, but recent assessments still favor forage species such as alfalfa. Table 4 lists several crops along with their P and N removal rates based on MAFRI's removal rates and implied land needs using MAFRI's manure examples. Note that alfalfa hay is still competitive in terms of the acres needed for manure management.

The acres need for a 500 sow operation used our total N calculations and MAFRI's assumed removal rates. Although alfalfa was an especially efficient user of nitrogen, it is still a competitive user of phosphorus compared to other crops.

Table 4: N and P Removal Rates and Implied Land Needs

Crop	Yield t/ac	Removal lb / ac		Acres for 500 Sow Farrow to finnish	
		N	P	N based	P Based
Spring Wheat	1.1	60.1	10.2	1,773	3,323
Grain Corn	2.5	97.2	19.2	1,097	1,769
Canola	0.8	67.6	15.8	1,578	2,149
Alfalfa	4.5	289.3	29.9	369	1,134
Corn Silage	4.5	155.6	27.8	685	1,222

Another key change which may impact the profitability of forage-based manure management has been the rise in grain prices observed in 2007 and 2008. With increased demand from ethanol production, grain prices in North America have seen price records smashed in the 2007-

08 crop year. Although prices are lower as this study goes to press, the price of wheat in Minneapolis is still above the record set prior to 2007 of $7.32/bu. The study by Kelwin argued that crop production in the Stuartburn area was not viable. Record high grain prices may make integration with crop land as profitable for hog producers as forage or beef operations. A further complication is that high grain prices have led to increased feed costs for hog producers at the same time that energy prices have increased. This threatens the viability of the entire hog sector in Manitoba. If these higher grain prices persist and forages suffer in terms of their ability to remove phosphorus, crop production might be a better alternative to the forage systems examined in this study. Unfortunately crop data was not available from the La Broquerie site.

A literature review of recent trends in manure application and farm level adoption of new technology is found below in Appendix C.

Regional Impact Simulations

Need for an Input-Output Model Based Analysis

The adoption of a new technology results in a change in the firm's production level and its input demand. When such a change in an industry or a firm's production occurs, the impacts of the change are felt through other sectors in the regional, provincial and national economies. Firms in an economy constantly adjust to resource availability, new technologies, globalization, and international trade. Other impacts on individual sectors in an economy include changes in: monetary (interest rate shifts) and fiscal (taxes and subsidies) policies, tax reforms, and other domestic policies. These changes result in the maintenance of production levels for some firms, while others develop new economic activities, replacing existing processes. As these changes occur, impacts are experienced by, but not limited to firms directly involved. Associated with these direct changes are the ripple effects which affect other local firms in the region, firms located in other regions through domestic and international trade, and through adjustments in households' consumption expenditures. Estimation of the ripple effects from a given change in sectoral output is typically captured by using an input-output (I-O) model of the economy.

An input-output model is a useful method of estimating secondary impacts of economic development projects. Secondary impacts in this context refer to any other changes, beyond those experienced by the sectors that are affected by a given initial change. An input-output based economic impact analysis is preferred for the following reasons: 1) every sector's impact is treated as unique, allowing its specific economic impacts, say in the hog sector, to be estimated; 2) different types of economic stimulus can be applied to undertake economic impact analysis. Thus, economic impacts of consumer spending, exports, or purchases by other sectors, for example, could be estimated uniquely; 3) development of the model can also be region specific, thereby allowing regional differences in the production processes, technology and trade patterns.

Description of an Input-Output Model

An input-output model is a representation of economic activities in region. It attempts to quantify, at a point in time, the economic interdependencies that exist in the economy. In these models, all economic activities are divided into one of two types of sectors – production sectors or final demand sectors. A production sector is comprised of firms that produce similar goods and services using a similar technology of production. Production sectors (such as agriculture, mining, manufacturing, construction) represent groups of firms in a region that produce a product or service for use either by another sector or by final demand sectors. The level of activity of these sectors is endogenized (determined within the model). Sectors representing final demand are generally the household (or consumers), governments, and foreign trade. The level of the final demand is exogenous to the model. All changes in the production sectors of a region are therefore, the result of the changes that occur in the final demand.

Assumptions of the Input-Output Model

An input-output model is based on several assumptions. The following ones are particularly noteworthy:

1. <u>Constant Technology and Fixed Technical Coefficients Assumption:</u> Under this assumption, the input structure of a sector remains fixed. In other words, the input structure does not change during the period of analysis. Inputs are used in constant proportion to output. Doubling the output implies the doubling of each input.

   This assumption has four implications:

   (a) No allowance is made for technological change which could alter factor-factor or factor-product relationships unless it is captured in the change in final demand imposed on the system;

   (b) Sectors cannot substitute inputs from one sector for inputs from another sector after the change in the final demand;

   (c) There is no scale or size economies of production; and

   (d) The **relative** prices of all goods and services remain constant.

2. <u>Homogeneity of Sectors:</u> The concept of a sector or industry in an input-output model is fundamental in constructing an empirical model. In reality there are many and diverse types of economic activities, which are not homogenous either in terms of the product produced or the nature of production technology used. Since it is not possible to collect all of the data needed to have a separate sector for each of these economic activities, grouping them into sectors is a requirement. In this aggregation process, an assumption of one product/one production process is made.

3. Additivity and Divisibility: The outputs of various firms are assumed to be additive to form the regional output. Thus the assumption that the total effect of several different activities is the sum of their separate effects is made. Furthermore, it is assumed that the output of a firm included in the sector is completely divisible. Thus, it is possible for a sector to produce any incremental change.

The technology used by the firms remains unchanged with the change in the level of output. In other words, the technology coefficients estimated below are fixed and do not change with the level of production. Each sector produces various goods in a fixed proportion. Doubling of output for a given good produced by a given firm is expected to be experienced by all firms producing that good and as such, they too are expected to double their output. The model assumes no supply constraints; if demand is present, the economy will grow to meet the required quantity of goods and services demanded.

Although some of these assumptions are violated in reality, this does not negate the usefulness of the input-output models. Most regional models have significant sectoral aggregation which has a muting effect on the departures from reality at smaller levels, because many are offsetting. And no other model has proven to be as useful at capturing the ripple effects described above.

Transactions Table

The heart of an input - output model is a 'Transactions Table'. This table presents all the sales and purchases of commodities by various 'sectors'. To make a model manageable, the number of sectors are typically restricted.. Any of the goods and services produced by a sector are called 'commodities'. A commodity can be a good or a service that is needed by other sectors in the economy.

A typical transactions table has four major components. A rudimentary transactions table is shown in Figure 1. Transactions are permitted among various goods producing sectors, or between goods producing sectors and the final demand sectors. Accordingly, the columns in the transactions table are divided into two types of purchases: 1) intermediate sales which include raw materials from other industries which are required by various firms in the region; 2) purchases by final demand agencies called final sales. The distinction between the two types of purchasers is as follows: intermediate sales are products to which further value will be added. These products will re-enter the economy but in a somewhat modified shape or form. The final demand agencies purchase goods for final consumption and these goods do not re-enter the economy. Four types of final demand agencies are typically included in the transactions table: consumers, government expenditures including investment, business investment, and exports.

The rows of the table depict the various industries or agents that sell their goods and services. These are also divided into two broad categories of sellers: 1) industries that have goods and services for sale to either other industries or for final consumption; 2) owners of labor and capital resources that are needed in the production of goods and services by various industries and/or by final demand agencies for the delivery of their goods and services.

The bottom row of the table provides the total inputs or purchases by the various agents / firms, while the column furthest to the right shows the sales of the industries, and the value added (gross domestic product) for the region. It should be noted that all industries are in perfect balance – their sales always equal purchases. If balance is not achieved due to inventories or other factors, adjustments are made to balance the economy.

Selling Sectors	**Purchasing Sectors**		**Total**
	Firms / Industries	**Final Demand Agencies**	
Firms / Industries	Sales of goods and services by one industry to other firms **(Intermediate Demand)**	Sales to consumers, government, businesses for investment, and for export **(Final Demand)**	Total Output of Firms
Primary Resource Owners	Payments by firms to workers, capital resource owners **(Value Added by Industries)**	Payments by final demand agencies to workers, capital resource owners **(Value Added by Final Demand Agencies)**	Total Value Added
Total Sales	Total Sales of Firms	Total Final Demand for Various Agencies	

Figure 1. An Overview of a Transactions Table for an Input-Output Model

Total Economic Impacts of a Project

Any economic change in a region starts with conception of a new project – be it expansion of an existing business, or a new endeavor. This would invariably entail some monetary outlays – some in capital funds, while others on a recurring basis over the life of the project. These expenditures initiate a sequence of changes in the regional economy. In addition some of the changes may even spill over to other regions of a country or even to other parts of the world.

Typically a new project can be conceived of having two district stages of development – the Investment Phase and the Operations Phase. The former is typically short-lived, and impacts are temporary in nature. The latter extends over the life of the project and the impacts created are somewhat more permanent in nature. Each of these phases creates economic impacts through monetary expenditures and their recirculation within the economic system.

There are typically two types of economic impacts that result from a new project: (1) 'backward linked impacts' which includes purchases of inputs from other industries in the region; and (2) 'downstream effects or forward linked impacts' which include sales of goods and services to

other industries for adding further value to the economic system. Let us take the example of a hog barn in the province of Manitoba. Expenditures related to construction and feed purchases will likely benefit the construction and feed manufacturing industries, among others. These industries will increase their own level of activity, and may need additional workers, etc. All these impacts are labeled 'Backward Linked Impacts'.
Various backward linked impacts result in two types of impacts on the region: 1) indirect impacts which occur though procurement of inputs from other industries located in the region; and (2) induced impacts which occur when a part of the total expenditure is paid to workers as wages and salaries, or retained by the owners of unincorporated business as profits, and are subsequently spent locally.

For each phase of a project (construction and operations) one can then identify three types of impacts on the region:

- Direct Impacts – created by the expenditures related to a project;
- Indirect Impacts – created by purchase of inputs needed for the production of goods and services for the direct impact; and
- Induced Impacts – created by spending of increases in the income of people in the region caused by the first two effects.

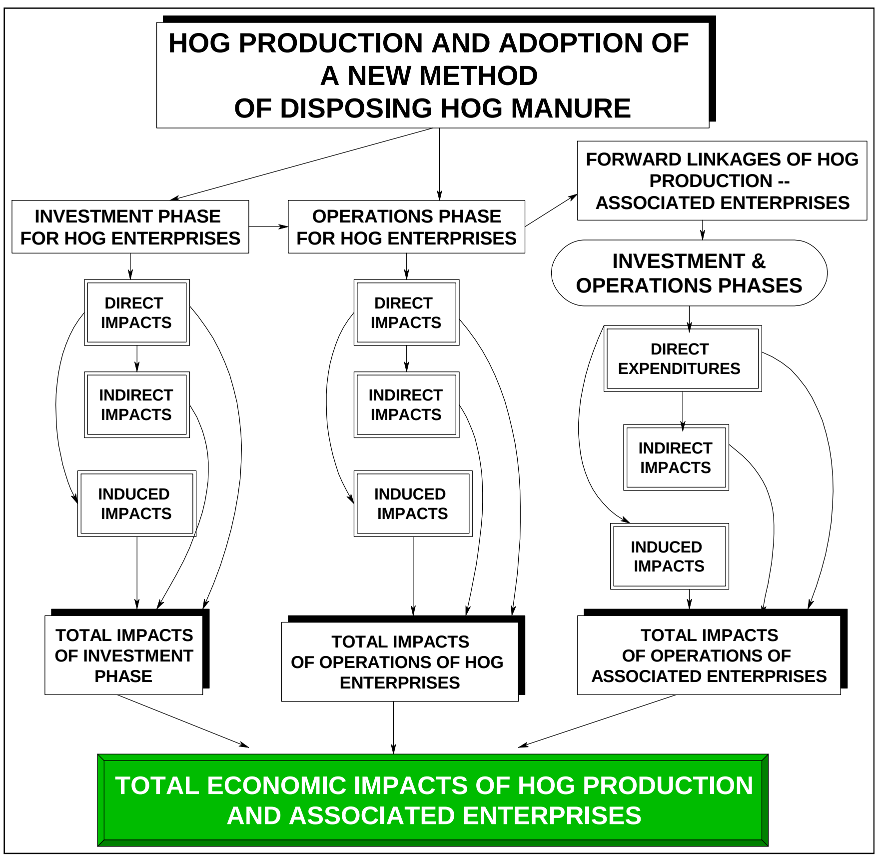

Figure 2. Classification of Impact of Hog Production and Manure Disposal Method

The downstream or forward linked impacts also a have similar type of impact typology. An example of this in the hog sector is the use of hog manure as a source of nutrient for further agricultural production. These developments would also have two distinct phases – investment phase and operations phase. Each of these phases would have direct expenditures by those using the facility, which would create indirect and induced impacts. As shown in Figure 2, total economic impacts of hog production and these associated enterprises are a sum of all these impacts.

Estimation of Economic Impacts of the Hog Production and Manure Disposal Project

Although direct expenditures associated with hog production can be estimated from budgeting like the farm level impacts calculated above, the estimates of indirect and induced impacts require further the use of a tool like the input-output (I-O) model.

Typically, building of an I-O model is very expensive. In Canada, only the federal government (through Statistics Canada) can afford to collect the data for such models. To be helpful to analysis like ours, federal models often need further work either in terms of delineation of a region or level of disaggregation of a sector to address detailed shifts production.

Basic data for this study model were obtained from Statistics Canada, Input-Output Division, Ottawa. It was based on the rectangular input-output accounting framework. In other words, it was based on the 'Commodity by Industry' system of accounting for transactions. All transactions were made in terms of commodities and any sector was allowed to produce more than one commodity. Economic impacts were generated using the sales of various sectors, contribution to gross domestic product of the region (GDP), imports into the region, and labor income. In addition, the model also estimated additional employment created by the project.

The study model was constructed with three regions: 1) Province of Manitoba, 2) the rest of Canada and 3) Canada as a whole. The sector and commodity disaggregation are identical for the three regions three regions and therefore, estimated impacts are comparable. Only Manitoba's impacts are presented below.

The study I-O model contains a total of 31 goods and services producing economic sectors. These are listed in Table 5. All other sectors, other than agriculture and manufacturing are standard Statistics Canada sectors for input-output analysis. The agriculture sector was split into five sub-sectors, crop farms, farrowing hog farms, finishing hog farms, cattle farms and other agricultural production. The list of sectors is used for the presentation of output of the model for any given scenario. In addition, the model is capable of estimating imports of goods and services within Canada (by province) as well as international imports. These are shown in Table 6.

The data required for running economic impacts of a scenario are in the form of various commodities. The model included a total of 74 commodities. These are listed in Table 7.

Table 5: List of Study Sectors in the Manitoba Input-Output Model

1 Crop Farms
2 Hog farms – Farrowing
3 Hog farms -- Feeder to Finish
4 Cattle farms
5 Other Agricultural Production
6 Forestry and Logging
7 Fishing, Hunting and Trapping
8 Support Activities for Agriculture and forestry
9 Mining and Oil and Gas Extraction
10 Utilities
11 Construction
12 Animal Slaughtering and Meat processing
13 Animal Feed
14 Other Manufacturing
15 Wholesale Trade
16 Retail Trade
17 Transportation and Warehousing
18 Information and Cultural Industries
19 Finance, Insurance, Real Estate and Rental and Leasing
20 Professional, Scientific and Technical Services
21 Administrative and Support, Waste Management and Remediation Services
22 Educational Services
23 Health Care and Social Assistance
24 Arts, Entertainment and Recreation
25 Accommodation and Food Services
26 Other Services (Except Public Administration)
27 Operating, Office, Cafeteria and Laboratory Supplies
28 Travel, Entertainment, Advertising and Promotion
29 Transportation Margins
30 Non-Profit Institutions Serving Households
31 Government Sector

Table 6: Primary Input Sectors and Trade Regions

No. and Primary Input Sectors and Trade Regions
32 Indirect Taxes
33 Subsidies
34 Labor Income
35 Other Operating Surplus
36 Imports NFLD
37 Imports PEI
38 Imports NS
39 Imports NB
40 Imports QU
41 Imports ON
42 Imports MN
43 Imports SK
44 Imports AB
45 Imports BC
46 Imports Territories
47 Imports Foreign
48 Other Leakages

Table 7: List of Commodities in the Study I-O Model

Comm. No.	Commodity Description	Comm. No.	Commodity Description
1	Grains	38	Communications services
2	Hogs	39	Other Utilities
3	Cattle	40	Wholesaling margins
4	Other agricultural products	41	Retailing margins and services
5	Forestry products	42	Gross imputed rent
6	Fish & seafood; hunting &trapping	43	Finance, insurance, and real estate serv.
7	Metal ores and concentrates	44	Business and computer services
8	Mineral fuels	45	Education, tuition and other fees services
9	Non-metallic minerals	46	Health and social services
10	Services incidental to mining	47	Accommodation services and meals
11	Meat and Meat Products	48	Other services
12	Dairy Products	49	Transportation margins
13	Fish Products	50	Operating, office, cafeteria and laboratory supplies
14	Feeds	51	Travel, entertainment, advertising and promotion
15	Other food products	52	Services provided by non-profit institutions serving households
16	Soft drinks and alcoholic beverages	53	Government sector services
17	Tobacco and tobacco products	54	Non-competing imports
18	Leather, rubber, and plastic products	55	Unallocated imports and exports
19	Textile products	56	Sales of other government services
20	Hosiery, clothing and accessories	57	Indirect taxes
21	Lumber and wood products	58	Subsidies
22	Furniture and fixtures	59	Labor Income
23	Wood pulp, paper and paper products	60	Other Operating Surplus
24	Printing and publishing	61	Imports NFLD
25	Primary metal products	62	Imports PEI
26	Fabricated metal products	63	Imports NS
27	Machinery	64	Imports NB
28	Motor vehicles, other transportation equipment and parts	65	Imports QU
29	Electrical, electronic and comm.. prod.	66	Imports ON
30	Non-metallic mineral products	67	Imports MN
31	Petroleum and coal products	68	Imports SK
32	Chemicals, pharmaceuticals and chemical products	69	Imports AB
33	Miscellaneous manufactured products	70	Imports BC
34	Residential building construction	71	Imports Territories
35	Non-residential construction	72	Imports Foreign
36	Repair construction	73	Other Leakages
37	Transportation and storage	74	Total Employment

Estimation of Employment Impacts

Since the objective of this study was to estimate both demand impacts as well as employment impacts of selected forage management scenarios, an employment module was added to the study I-O model. The employment module contained the employment coefficient based on Leontieff employment function. It is a ratio of employment in that sector divided by the total sales (output) of that sector.

Types of Impacts Generated

The study I-O model generates two types of economic impacts of an economic development activity:

- Type I economic impacts, which include direct changes plus indirect changes (through the sale of goods and services to the direct impact sector) in various sectors of the economy. In this model, household income is exogenous and is not assumed to be spent within the regional economy.

- Type II economic impacts, which include direct, indirect and induced effects from the aforesaid economic activity. Here, the assumption is that the households earn wages and salaries (plus other sources of income), which is spent concurrently within the economy.

The second type of impacts are generated by making household activities (earning of income, and the resulting consumer expenditures) endogenous within the model. In order to endogenize the households in the model, it was necessary to obtain an estimate of the propensity to consume. This propensity measures the proportion of total income earned that is spent on goods and services by households within a given time period (typically a 12-month period). Propensity can be measured as an average or on the margin. In this study, an attempt was first made to estimate the marginal propensity to consume. The estimated marginal propensity to consume from the model was greater than one. Since this reflected a situation that could not be sustained in the long run (they are spending more than they make), this estimate was not used. As an alternative, average propensity to consume was estimated. During 2002 to 2006 period, the average propensity to consume was estimated to be 0.80. This estimate was used in the calculation of induced impacts from hog production and associated agricultural enterprises in the province.

Study Scenarios

Three impact scenarios were estimated using the study I-O model based on the farm level impacts estimated above: 1) in Case One the impacts of a large hog barn with conventional manure disposal to crop land is estimated[2]; 2) in Case Two it is assumed that the hog barn now owns sufficient quantities of hay land such that all hog manure produced by the operation can all be applied and that the hay produced is sold into the market place; and 3) in Case Three the hog barn owns sufficient quantities of pastureland such that all hog manure produced by the

[2] No economic benefit is assumed for this manure.

operation can be applied and the farm profits from the increased weight of the cattle grazing this pasture.

Results of Economic Impact Analysis for Firm Level Production

In this section economic impacts for each case farm are evaluated. Under each of the last two cases, ownership of all assets needs is assumed to be the hog barn owner.

Case One: Economic Impacts of a Hog Barn

The base hog barn was a farrow-to-finish barn with 500 sows. The barn sold a total of 10,216 pigs, for a total market value of $1.62 million (see the Farm Level impacts above for details of the operation). Through various linkages with other industries in the province, and through re-spending of income earned through hog production, sales of various industries in the province increased by $3.4 million (Table 8). This increase results in a gain of provincial gross domestic product (GDP) of $1.6 million, which includes income to various households of $1.1 million. The income is earned through 21 additional jobs in the province.

Table 8: Economic Impacts of Large Hog Barn on the Manitoba Economy (Case One), Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Thousand Dollars			Person-years
Direct	$1,624	$794	$648	5.5
Indirect	$971	$394	$188	6.4
Induced	$844	$450	$293	9.0
Total	$3,439	$1,686	$1,129	20.8

Case Two: Disposal of Hog Manure through Application on Forage Land Harvested as Hay

In this scenario the hog barn produced all the pigs for market as in the case above, but instead of disposing hog manure in conventional manner, the farm purchased 862 acres of land to grow forages. These forages were harvested and sold in the current market. The total sales of farm with this additional enterprise increased to $1.7 million, which increased sales of all other industries in the province by $3.5 million per annum (Table 9). There was an increase noted for all other indicators compared to Case One. Provincial GDP increased by $1.7 million. Also some 21 jobs were created by this farm type. Since hay production does not require a large amount of manpower, the change in employment is not much different from the basic hog barn scenario. However, the other three indicators show a slight gain when hog manure is applied to forage land harvested as hay. Implicit in this case is the assumption that market demand for the hay produced exists within a close proximity to the hog barn. If such were not the case, transportation costs associated with movement of this very bulky product, may change the relative economics of this method hog manure disposal.

Table 9: Economic Impacts of Large Hog Barn with Hog Manure Used for Hay Production (Case Two) on the Manitoba Economy, Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Thousand Dollars			Person-years
Direct	$1,694	$827	$668	5.6
Indirect	$986	$405	$193	6.5
Induced	$869	$510	$302	9.2
Total	$3,549	$1,742	$1,163	21.4

Case Three: Disposal of Hog Manure through Application on Forage Land Grazed by Cattle

Instead of applying the hog manure to a hay field, it was applied to a pasture stocked with a sufficient number of cattle to graze the forage produced. The hog barn was assumed to have purchased 862 acres of forage land and equipped it with wire fencing, waterers and a handling facility. 1001 calves were placed on this land, base on the carrying capacities of the La Broquerie site. Impacts of the scenario are shown in Table 10. Results indicate that farm with the added cattle enterprise had sales of $2.37 million per annum. Provincial GDP under this scenario is estimated to be $2.3 million, including $1.5 million for household incomes. The added cattle enterprise also impacts the labor demand, as the total employment created now is 30 full-time equivalent workers.

Table 10: Economic Impacts of Large Hog Barn with Hog Manure used for Pastures (Case Three) on the Manitoba Economy, Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Thousand Dollars			Person-years
Direct	$2,373	$945	$793	5.6
Indirect	$1,837	$707	$323	12.9
Induced	$1,112	$652	$386	11.8
Total	$5,323	$2,304	$1,502	30.3

Results of Industry Level Hog Manure Disposal

If it is assumed that the total number of pigs sold in Manitoba is 8.5 million[3] (Statistics Canada, 2008) and that all operations adopted one of the three hog manure management strategies described above with comparable technology and costs of production, the resulting economic impacts are as depicted in Tables 11 to 13.

Table 11: Economic Impacts of Manitoba Hog Production on the Manitoba Economy, Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Million Dollars			Person-years
Direct	$1,351	$660	$539	4,576
Indirect	$808	$331	$156	5,304
Induced	$702	$412	$244	7,467
Total	$2,862	$1,403	$939	17,347

In Manitoba's provincial economy, the hog industry is responsible, either directly or through its linkages with other economic sectors, for sales of $2.9 billion annually. It contributes to the provincial GDP in the amount of $1.4 billion, of which almost one billion dollars is paid out to the workers and owners of the unincorporated businesses (including producers in the hog industry). Directly or indirectly some 17,347 person-years of employment can be attributed to this industry.

Table 12: Economic Impacts of Manitoba Hog Production with Manure Disposal on Forage Land Harvested as Hay on the Manitoba Economy, Selected Indicators

Type of Impact	of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Million Dollars			Person-years
Direct	$1,409	$688	$556	4,659
Indirect	$820	$337	$160	5,422
Induced	$723	$424	$251	7,693
Total	$2,952	$1,450	$967	17,774

[3] The production is based on quarterly output of 2.125 million which is conservative based on recent quarterly estimates from Statistics Canada.

Table 13: Economic Impacts of Manitoba Hog Production with Manure Disposal on Forage Land Grazed by Cattle on the Manitoba Economy, Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Million Dollars			Person-years
Direct	$1,974	$786	$659	4,659
Indirect	$1,528	$588	$269	10,722
Induced	$925	$543	$321	9,842
Total	$4,427	$1,917	$1,249	25,223

If we assume that all of the hog farms in the input output model also bought forage land and applied hog manure, the industry's economic contributions increase slightly. As shown in Table 8, changes are rather small. Total employment contribution of the hog industry under this method of manure disposal is estimated at 17.774 – an increase of only 427 person-years over the conventional method of manure disposal. However, the scenario is economically feasible – the direct net return to producer is higher than that under the conventional method.

When hog manure is added to the pasturelands, and cattle are raised, economic contributions of the mixed hog-cattle industry improve. Now, the hog barn plus pasturelands (called the sector hereinafter) create a sale of almost $2 billion annually, which after taking into account all the multiplier activity of the sector results in an increased sale of $4.4 billion. Provincial GDP of this sector is almost $2 billion, including $1.2 billion as household incomes. The sector also results in creating, through direct and secondary linkages, 25,223 jobs in the province.

Relative Economic Contribution of Alternative Hog Manure Disposal Methods

On the basis of macroeconomic impacts, it is logical to question: "Which of the two method of manure disposal method are more desirable economically?" The answer is provided in Table 14. The economic impacts of changing from conventional methods of manure disposal to applying it on the forage lands is relatively small compared to the same manure being applied to the forage land grazed by cattle. This latter strategy for manure disposal adds almost $500 million to the provincial GDP, and creates 7,900 jobs.

Table 14: Increased Economic Impacts of Alternative Manure Disposal Method on the Manitoba Economy, Selected Indicators

Type of Impact	Sales of Industries	Gross Domestic Product (at Market Prices)	Household Incomes	Employment
	Million Dollars			Person-years
Disposal through Forage Lands	$90	$47	$28	427
Disposal through Pasturelands with Cattle	$1,565	$514	$310	7,876

Limitations of the Regional Analysis

The above analysis of the economic impact of hog production and associated enterprises, through manure disposal, has some limitations. These include:

1. Hog production in Manitoba is linked to several industries that add value to the pigs (and other products) produced. These forward linkages and their associated economic impacts are not included in the above analysis.

2. Province of Manitoba has trade linkages with other regions of Canada. These linkages result in imports into the province, which increases the economic activities in other parts of Canada. These impacts were not included here.

3. The two scenarios are based on the assumption that Canadian demand for hay and cattle are perfectly elastic. In other words, increasing the production of these commodities would have no impact on their prices. This assumption needs to be tested in future studies.

Conclusions

This study estimated the impact of changing manure management strategies for Manitoba hog producers to include forages. Farm level impacts estimated using yield effects from the manure based on field trials from a University of Manitoba project in La Broquerie MB, suggest 500 sow hog barns incorporating beef farms to make use of their manure would make nearly $50,000 more than hog barns who just gave the manure away. This was a 9.6% increase in income. Incorporating a hay operation was also profitable but it only increased income by 2.2%.

A regional analysis based on these farm budgets suggested that 8.5 million head of finished hogs represents some $660 million in gross domestic product (GDP) for Manitoba and over 4,500 jobs. Indirect and induced effects from the input suppliers to the industry and from spending by income earned throughout the supply chain added another $740 million in GDP and another 12,000 jobs.

If the original use of the manure was not productive, the inclusion of a cattle grazing system to make use of the manure from the 8.5 million hogs would add another $500 million in total GDSP effects and thousands more jobs.

Clearly there are some economic benefits of forage and grazing based manure management systems in Manitoba. Recent challenges arising from Phosphorus based regulation and rising energy and grain prices might change these findings considerably.

Appendix A – Complete Budgets

Base Case – 500 Sow Farrow to Finish

Income		
# of calves		
Calf Rev		
Hay sales		
Rate per market pig	**$159.00**	
Number of pigs marketed	**10,216**	
		$1,624,314
Total Income		**$1,624,314**
Operating Expenses		
Hog		
Feed Cost (66% feeders)		$560,173
Feeder Cost		$0
Veterinary Medicine & Supplies		$14,625
Maintenance & Repairs		$13,290
Hydro & Propane		$35,000
Insurance		$28,989
Manure Costs		$28,295
Office Supplies		$1,000
Levy, Marketing & Transportation		$50,773
Insemination & Replacement Costs		$47,156
Property Taxes		$7,500
Interest on Operating Cost		$12,715
Total Operating Costs		**$799,516**
Labour Costs		
Hogs		$140,400
Forage		
Beef		
Total Labour Costs		**$140,400**
Fixed Costs		
Depreciation:		
Hog		
Buildings & Manure Storage		$43,684
Equipment		$83,072
Total Depreciation Cost		**$126,756**
Investment:		
Hog		
Land for barns land(20ac)&site prep		$1,400
Buildings & Manure Storage		$30,498
Equipment		$17,768
Breeding Herd		$5,282
Total Investment Cost		**$54,948**
Total Fixed Costs		**$181,704**
Total Expenses		$1,121,620.33
Net Income/hog		$49.21

Forage Case – 500 Sow Farrow to Finish with 862 Acres of Forage Land

Income		
Hay sales		**$69,450.12**
Rate per market pig	**$159.00**	
Number of pigs marketed	**10,216**	
		$1,624,314
Total Income		**$1,693,764**
Operating Expenses		
Forage		
Field Fuel Costs		13257.56
Moving Costs		7818.34
Repairs & Maintenance		1051.64
Land Taxes		3448
Miscellaneous		5172
Interest on Operating		1224.04
Hog		
Feed Cost (66% feeders)		$560,173
Feeder Cost		$0
Veterinary Medicine & Supplies		$14,625
Maintenance & Repairs		$13,290
Hydro & Propane		$35,000
Insurance		$28,989
Manure Costs		$28,295
Office Supplies		$1,000
Levy, Marketing & Transportation		$50,773
Insemination & Replacement Costs		$47,156
Property Taxes		$7,500
Interest on Operating Cost		$12,715
Total Operating Costs		**$831,488**
Labour Costs		
Hogs		$140,400
Forage		$6,475
Total Labour Costs		**$146,875**
Fixed Costs		
Depreciation:		
Forage and beef		
Machinery		$4,353.10
Storage		$448.24
Hog		
Buildings & Manure Storage		$43,684
Equipment		$83,072
Total Depreciation Cost		**$131,558**
Investment:		
Forage and beef		
Land		$13,792.00
Machinery		$956.82
Storage		$181.02
Hog		
Land for barns land(20ac)&site prep		$1,400
Buildings & Manure Storage		$30,498
Equipment		$17,768
Breeding Herd		$5,282
Total Investment Cost		**$69,877**
Total Fixed Costs		**$201,435**
Total Expenses		$1,179,798.35
Net Income		$513,965.56
Net Income/hog		$50.31

Beef Case – 500 Sow Farrow to Finish with 862 Acres of Pasture for Grazing/Backgrounding

Income		
# of calves		207
Calf Rev		**$154,709**
Rate per market pig	**$159.00**	
Number of pigs marketed	**10,216**	
		$1,624,314
Total Income		**$1,779,023**
Operating Expenses		
Beef		
Salt, Vitamins & Minerals		$124
Feeder Cost		$125,691
Yardage		$620
Pasture Checking		$500
Veterinary Medicine & Supplies		$2,854
Insurance		$754
Selling Cost		$5,843
Operating Interest		$3,090
Land Taxes		$3,448
Hog		
Feed Cost (66% feeders)		$560,173
Feeder Cost		$0
Veterinary Medicine & Supplies		$14,625
Maintenance & Repairs		$13,290
Hydro & Propane		$35,000
Insurance		$28,989
Manure Costs		$28,295
Office Supplies		$1,000
Levy, Marketing & Transportation		$50,773
Insemination & Replacement Costs		$47,156
Property Taxes		$7,500
Interest on Operating Cost		$12,715
Total Operating Costs		**$942,441**
Labour Costs		
Hogs		$140,400
Forage		$0
Beef		**$623**
Total Labour Costs		**$141,023**
Fixed Costs		
Depreciation:		
Forage and beef		
Fence and Waterers		$2,900
Hog		
Buildings & Manure Storage		$43,684
Equipment		$83,072
Total Depreciation Cost		**$129,656**
Investment:		
Forage and beef		
Land		$13,792
Fence and Waterers		$2,180
Machinery		$0
Hog		
Land for barns land(20ac)&site prep		$1,400
Buildings & Manure Storage		$30,498
Equipment		$17,768
Breeding Herd		$5,282
Total Investment Cost		**$70,920**
Total Fixed Costs		**$200,576**
Total Expenses		$1,284,040.34
Net Income		$494,982.45
Net Income/hog		$48.45

Appendix B – Price Averages Jan. 1997 to March 2008

Statistics Canada, (2008b) – CANSIM Crop Prices

	Feed Wheat	Feed Barley	Canola	Peas	Hogs	Canola Meal
	$/tn	$/tn	$/tn	$/tn	$/ckg	$/tn
1/1/1997	163.44	104.32	381.35	220.00	192.13	251.09
2/1/1997	146.94	105.27	388.33	225.00	190.79	259.68
3/1/1997	149.40	104.72	397.60	240.00	180.62	283.24
4/1/1997	153.40	104.77	400.71	230.00	196.72	287.66
5/1/1997	133.68	101.07	395.64	230.00	211.99	303.12
6/1/1997	126.43	93.74	390.30	210.00	210.54	264.59
7/1/1997	120.27	87.74	363.06	190.00	220.39	249.37
8/1/1997	123.91	94.31	401.59	195.00	206.70	238.81
9/1/1997	138.19	93.81	343.03	195.00	188.85	186.04
10/1/1997	146.69	110.00	383.65	192.00	173.99	207.89
11/1/1997	143.95	113.65	398.45	195.00	169.58	222.86
12/1/1997	144.54	107.63	381.39	195.00	160.80	190.95
1/1/1998	152.05	102.96	356.96	200.00	134.88	172.05
2/1/1998	142.02	99.97	385.07	200.00	136.51	158.06
3/1/1998	134.10	98.37	395.22	190.00	132.67	154.63
4/1/1998	142.55	94.51	396.62	185.00	134.28	163.22
5/1/1998	148.72	100.19	408.29	180.00	166.01	171.32
6/1/1998	140.23	96.86	402.18	180.00	166.78	165.43
7/1/1998	124.15	93.71	400.95	175.00	142.06	151.93
8/1/1998	105.85	79.33	347.47	160.00	134.55	129.59
9/1/1998	108.87	83.89	340.72	150.00	118.43	124.68
10/1/1998	113.86	97.53	357.60	160.00	111.99	127.38
11/1/1998	121.26	95.32	372.37	155.00	72.24	129.35
12/1/1998	116.51	91.33	368.71	160.00	60.43	134.50
1/1/1999	127.82	90.46	366.12	158.00	110.72	148.74
2/1/1999	117.96	87.41	346.85	163.00	115.83	151.93
3/1/1999	118.29	85.05	328.99	155.00	114.40	146.53
4/1/1999	122.21	86.49	344.73	155.00	127.25	137.69
5/1/1999	139.25	86.63	331.65	165.00	151.52	150.46
6/1/1999	138.35	89.25	320.78	173.00	139.75	145.79
7/1/1999	100.97	83.50	302.88	162.00	131.22	150.46
8/1/1999	97.92	73.18	248.88	150.00	153.99	142.36
9/1/1999	89.11	75.28	243.47	140.00	143.21	137.69
10/1/1999	82.97	74.83	238.13	153.00	143.34	129.59
11/1/1999	82.43	74.86	237.12	157.00	141.43	136.22
12/1/1999	88.56	71.63	228.16	166.00	152.49	148.98
1/1/2000	85.34	73.90	225.66	180.00	155.87	158.31
2/1/2000	83.90	75.55	223.56	160.00	180.76	161.75
3/1/2000	86.99	77.05	228.97	166.00	179.10	160.52
4/1/2000	86.41	75.35	237.36	167.00	203.29	157.08
5/1/2000	90.97	71.47	227.38	165.00	204.92	170.09
6/1/2000	89.64	75.44	217.91	150.00	205.58	161.50
7/1/2000	89.07	73.42	204.17	142.00	203.04	148.98
8/1/2000	95.23	73.65	213.13	124.00	182.19	175.25
9/1/2000	91.39	72.42	216.77	120.00	175.53	195.13
10/1/2000	91.03	80.47	212.81	118.00	173.48	163.71
11/1/2000	93.95	88.96	223.69	127.00	157.08	178.19
12/1/2000	99.48	91.38	224.26	140.00	169.69	193.16
1/1/2001	99.09	83.18	227.02	135.00	155.27	197.34
2/1/2001	102.10	86.41	230.12	141.00	166.32	206.42
3/1/2001	94.82	91.78	248.43	151.00	197.18	198.07
4/1/2001	101.71	92.55	255.64	147.00	202.93	190.71
5/1/2001	99.76	96.38	265.77	140.00	212.52	202.73
6/1/2001	96.71	98.28	278.07	151.00	218.50	226.79
7/1/2001	99.32	111.32	317.14	145.00	217.64	222.37
8/1/2001	106.35	113.02	307.54	140.00	214.90	208.63
9/1/2001	108.99	116.29	289.52	152.00	196.32	211.82
10/1/2001	123.13	115.59	292.16	161.00	177.98	207.15
11/1/2001	124.74	121.67	310.34	188.00	154.39	207.64
12/1/2001	123.85	121.36	293.30	190.00	149.93	194.39
1/1/2002	137.61	127.30	285.14	217.00	170.00	196.11
2/1/2002	137.12	126.28	317.32	232.00	177.10	196.84
3/1/2002	138.49	125.56	306.32	205.00	167.88	219.67
4/1/2002	146.97	112.68	297.04	215.00	150.38	207.64
5/1/2002	147.53	122.14	308.81	222.00	152.23	212.55
6/1/2002	138.29	126.50	327.37	221.00	158.33	200.77
7/1/2002	138.74	143.75	352.71	200.00	171.67	216.97

	Feed Wheat	Feed Barley	Canola	Peas	Hogs	Canola Meal
	$/tn	$/tn	$/tn	$/tn	$/ckg	$/tn
8/1/2002	132.02	151.43	372.87	200.00	155.69	205.19
9/1/2002	137.49	153.52	384.74	200.00	121.47	220.65
10/1/2002	135.68	154.44	389.84	220.00	142.00	210.34
11/1/2002	147.12	161.30	405.04	210.00	132.87	208.63
12/1/2002	157.01	159.39	405.65	230.00	141.14	222.12
1/1/2003	165.68	151.39	402.67	215.00	146.69	210.83
2/1/2003	155.34	150.49	400.66	225.00	155.27	208.87
3/1/2003	156.33	149.82	378.83	215.00	151.37	195.62
4/1/2003	148.44	142.64	360.17	190.00	152.67	184.33
5/1/2003	143.45	122.09	349.63	185.00	170.28	188.25
6/1/2003	142.37	119.98	331.28	165.00	178.29	192.67
7/1/2003	132.25	116.66	321.11	160.00	174.27	186.29
8/1/2003	117.32	102.37	315.85	150.00	166.27	175.49
9/1/2003	121.72	100.03	317.71	160.00	158.97	185.80
10/1/2003	122.66	100.18	334.73	155.00	148.68	206.17
11/1/2003	128.65	101.23	341.09	180.00	137.28	219.67
12/1/2003	127.29	103.99	344.84	180.00	136.77	214.27
1/1/2004	129.87	104.72	349.10	185.00	136.77	226.79
2/1/2004	131.37	103.33	355.31	203.00	147.38	240.04
3/1/2004	135.39	106.29	368.96	189.00	173.41	269.99
4/1/2004	143.55	116.99	377.98	201.00	175.84	281.52
5/1/2004	152.22	122.85	383.76	212.00	194.40	248.39
6/1/2004	151.00	125.39	389.35	208.00	192.99	260.90
7/1/2004	151.52	116.90	380.38	200.00	204.59	213.29
8/1/2004	134.87	97.94	364.33	173.00	199.01	173.04
9/1/2004	112.65	86.68	338.16	160.00	187.57	155.36
10/1/2004	92.31	85.46	311.75	172.00	177.93	143.58
11/1/2004	86.74	83.21	288.52	180.00	175.31	136.71
12/1/2004	81.65	84.02	279.05	150.00	174.30	138.43
1/1/2005	83.01	84.50	261.48	162.00	173.90	158.06
2/1/2005	83.69	80.27	246.94	142.00	173.50	144.57
3/1/2005	79.93	80.61	265.90	138.00	170.50	165.18
4/1/2005	80.11	78.90	265.50	130.00	170.90	164.45
5/1/2005	79.52	85.44	271.71	141.00	188.69	165.67
6/1/2005	85.80	77.13	281.44	142.00	170.33	187.27
7/1/2005	86.63	78.66	272.08	142.00	166.60	208.87
8/1/2005	84.17	75.15	258.99	131.00	168.81	163.46
9/1/2005	89.72	72.07	248.29	128.00	161.20	147.27
10/1/2005	90.45	81.95	254.00	123.00	153.99	142.85
11/1/2005	98.67	85.22	256.01	129.00	142.40	160.27
12/1/2005	114.11	90.53	264.46	130.00	140.50	184.08
1/1/2006	109.80	91.40	268.12	132.00	132.10	154.63
2/1/2006	115.81	85.88	244.84	129.00	134.61	142.60
3/1/2006	108.22	80.33	268.51	128.00	138.29	140.64
4/1/2006	110.00	87.92	261.37	130.00	130.87	138.43
5/1/2006	112.00	86.63	275.08	138.00	149.41	148.98
6/1/2006	114.73	85.99	271.62	155.00	164.60	148.49
7/1/2006	115.64	79.99	279.90	144.00	159.50	154.14
8/1/2006	116.47	78.55	278.75	123.00	162.10	141.62
9/1/2006	124.05	90.15	277.24	142.00	151.21	131.07
10/1/2006	137.05	110.23	288.93	156.00	148.90	146.77
11/1/2006	141.54	123.98	308.52	163.00	141.80	159.78
12/1/2006	146.64	132.92	325.86	179.00	140.61	151.19
1/1/2007	153.47	133.85	340.82	180.00	142.11	166.65
2/1/2007	164.62	138.88	347.43	194.00	155.27	182.12
3/1/2007	161.13	145.21	348.50	214.00	143.92	175.00
4/1/2007	161.13	147.13	345.05	238.00	149.91	157.08
5/1/2007	162.42	148.66	357.78	250.00	163.91	151.44
6/1/2007	163.73	152.73	363.77	240.00	160.63	157.33
7/1/2007	158.55	153.35	369.48	220.00	149.52	153.89
8/1/2007	152.67	134.51	371.24	215.00	149.52	137.94
9/1/2007	152.94	154.92	379.97	220.00	132.17	161.50
10/1/2007	167.96	153.88	385.63	235.00	117.92	172.55
11/1/2007	158.57	157.22	399.63	255.00	98.33	182.12
12/1/2007	187.27	168.63	415.79	270.00	107.01	217.46
1/1/2008	202.91	180.02	446.98	310.00	101.01	242.25
2/1/2008	228.29	198.68	506.13	325.00	107.01	262.13
3/1/2008	263.43	219.16	543.26	346.00	106.50	272.69
	Average Values					
	125.3	**106.4**	**323.1**	**179.0**	**72.1**	**184.2**
	Feed Wheat	**Feed Barley**	**Canola**	**Peas**	**Hogs**	**Canola Meal**

<u>Appendix C – A Literature Review of Liquid Manure Application and Adoption</u>

Prepared by Oteng Mondongo

Current Profile of Liquid Manure and Manure Application Methods

Manure Application Methods

Liquid manure application methods have changed dramatically between the census year 2001 and 2006. Both Canada and Manitoba show a consistent movement of the disposal method, with an increased method of injecting manure into the soil. According to Statistics Canada in 2006 880 Manitoba farms reported they injected liquid manure as compared to 430 farms in 2001, this shows a 105 percentage increase in the injection of manure into the soil (see Table A2). Canada also shows the same trend with an increase of 428 % between the year 2001 and 2006. This increase in injecting manure is accompanied by a decrease of manure disposal methods that leaves manure on the soil. Manure not incorporated into the soil decreased by 60 and 37 percent for Manitoba and Canada, respectively. Irrigation of manure also shows a downward shift, decreasing by 57 and 55 percentages for Manitoba and Canada, respectively. Tables A1 to A4 show liquid manure disposal in Canada, Manitoba and Saskatchewan during 2001 and 2006. Furthermore the 2006 census shows the amount of manure applied to hay and pastures. Irrigation of manure is the main application method for both Manitoba and Canada.

Timing of Manure Application

According to Beaulieu (2001), the timing of manure application depends on various factors such as weather conditions, stage of crop growth, labor availability and manure storage capacity. "Nationally (2001), FEMS results show that farms applied manure mostly in the fall (35.4% of applications), followed closely by applications in the spring (33.2%). About one-quarter (25.9%) of manure applications were performed in the summer months. In comparison, 5.5% of manure applications, by far the lowest proportion, were in winter, generally considered an unfavorable time because of the potential for run-off due to frozen ground."

Table A1: Liquid Manure Not Incorporated into Soil

Census Year	2001			2006					
Geographic name	**Farms reporting**	**Acres**	**Hectares**	**farms reporting**	**acres**	**hectares**	**farms reporting manure on field crops**	**farms reporting manure on hay and pasture**	**farms reporting manure on other land**
Canada	16,461	1,774,618	718,162	10,363	1,149,963	465,373	3,924	8,226	212
Manitoba	901	99,869	40,416	363	45,229	18,304	172	222	23
Saskatchewan	355	41,762	16,900	123	15,224	6,161	90	43	1

Source: Statistics Canada (2001 and 2006).

Table A2: Liquid Manure Injected or Incorporated into Soil

Census Year	2001			2006					
Geographic area	Farms reporting	Acres	Hectares	Farms Reporting	acres	hectares	farms reporting manure on field crops	farms reporting manure on hay and pasture	farms reporting manure on other land
Canada	1,958	312,110	126,306	10,338	1,526,339	617,687	8,924	2,539	290
Manitoba	430	94,254	38,143	880	215,145	87,066	756	187	25
Saskatchewan	275	56,755	22,968	397	96,110	38,894	356	51	7

Source: Statistics Canada (2001 and 2006).

Table A3: Liquid Manure Applied by Irrigation

Census Year	2001			2006					
Geographic Area	Farms reporting	Acres	Hectares	farms reporting	acres	hectares	farms reporting manure on field crops	farms reporting manure on hay and pasture	farms reporting manure on other land
Canada	1,297	119,320	48,287	579	53,089	21,484	411	248	31
Manitoba	35	5,156	2,087	33	5,548	2,245	16	23	1
Saskatchewan	18	2,477	1,002	11	2,272	919	8	4	0

Source: Statistics Canada. (2001 and 2006).

Table A4: Manure and Manure Application Methods for Hay and Pastures, 2006

Geographic area	**Manure Incorporated**	**Manure not incorporated**	**Manure Irrigation**
	Number of farms reporting		
Manitoba	187	222	23
Canada	2,539	8,226	248

Source: Statistics Canada (2001 and 2006).

Manure Management Practices and Technology

Development of Technologies

The hog industry has expanded over the last decades, leading to a challenge of too much manure and less land for disposal. According to the Manitoba Livestock Manure Management Initiative – (MLMMI, Undated), the hog sector in Manitoba expanded from less than 2 million in1980 to more than 8 millions in 2006.

The main objective of manure management and technological systems is to dispose manure in a more environmental and economical friendly way. Several options exist. Major ones have been summarized in Cornell University (2004).

According to Cabrera et al. (Undated), manure is an excellent source of major plant nutrients such as nitrogen, phosphorus and potassium and the secondary nutrients that plants require. Despite this nutrients manure pose a great threat to water and Air quality. According to Jones (1969), there are four objectives of manure treatment:

1. Control of objectionable odors
2. Reduce nitrogen content for land application
3. Reduce organic carbon and fertilizing nutrients for release to surface water
4. Improve characteristics of waste for ease of handling.

Farmers have adopted different management and technological systems to make use of manure efficiently, the following technological systems are some of those farmers use;

1. Anaerobic digestion
2. Aerobic
3. Solid liquid separation
4. composting
5. Feed additives

According to Robbins (2005), technology is not a cure for manure management problems plaguing both large concentrated livestock operations and small farms. The technologies are not failsafe -- the capability of the facility owner and operator is a crucial piece of the puzzle. Manure treatment technologies must be chosen based on the specific site conditions, current infrastructure, management practices, and treatment objectives of a farm; a technology that is successful on one farm will not necessarily be successful at a neighboring farm. Robbins discussed the advantages and disadvantages, how the technology works, and variations on the technology design. The table below shows a summary of different technologies and their potential benefits; Hog manure to be used for forage and pasture production is be best suited to the anaerobic digestion because the end product of the system is a nutrient rich liquid that can be used for crop production.

According to Wright (2001), anaerobic digestion is the breakdown of complex organic material by microorganisms in the absence of oxygen (Table A5). The end products of anaerobic digestion of manure include biogas that is comprised of methane, carbon dioxide, and some trace gases; and stabilized organic matter. There are several types of anaerobic digesters being employed on farms for manure digestion including plug flow digesters, mixed digesters, and fixed film digesters. The most appropriate digester type depends primarily upon incoming biomass and manure characteristics and manure management goals.

Table A5: Comparison of Different Manure Management Technologies

Chapter Number	Chapter Name	Treatment Process	Reduce Nitrogen	Reduce Phosphorus	Reduce Biochemical Oxygen Demand	Stabilize Manure	Reduce Manure Volume	Reduce Pathogens	Reduce Manure Gases	Reduce Odor	Reduce Ammonia Volatilization	Operate at Low Temperatures	Minimal Footprint	Low Energy Requirement	Create Biogas	Create Value-Added Products
2	Storage Covers	Bank-to-bank							✓	✓	✓	✓	✓	✓		
		Balloon							✓	✓	✓	✓	✓			
		Modular							✓	✓	✓	✓	✓	✓		
3	Solids Separation	Source separation								✓	✓	✓	✓			
		Gravity separation								✓		✓		✓		
		Mechanical separation								✓		✓	✓			
		Chemical separation								✓		✓	✓	✓		
4	Aerobic Digestion	Aerobic digestion	✓	✓	✓	✓		✓	✓	✓	✓	✓				
5	Anaerobic Digestion	Mixed reactor				✓		✓	✓	✓					✓	
		Fixed film				✓		✓	✓	✓					✓	
		Plug flow				✓		✓	✓	✓					✓	
		Ambient lagoon				✓		✓	✓	✓					✓	
		Heated mixed lagoon				✓		✓	✓	✓		✓			✓	
6	Nitrification-Denitrification	Nitrification-denitrification	✓		✓						✓					
7	Composting	Unaerated static pile				✓	✓	✓	✓	✓	✓	✓		✓		✓
		Aerated static pile				✓	✓	✓	✓	✓	✓	✓				✓
		Windrow				✓	✓	✓	✓	✓	✓	✓		✓		✓
		In-vessel				✓	✓	✓	✓	✓	✓	✓	✓			✓
		Pit				✓	✓	✓	✓	✓	✓	✓		✓		✓
		In-barn				✓	✓	✓	✓			✓	✓	✓		✓
8	Constructed Wetlands	Open water	✓		✓			✓	✓					✓		
		Subsurface flow	✓		✓			✓	✓	✓	✓			✓		
		Floating aquatic	✓		✓			✓	✓							
		Reciprocating	✓		✓			✓	✓	✓	✓					
9	Miscellaneous Treatment Technologies	Black soldier fly	✓	✓		✓	✓	✓		✓			✓	✓		✓
		Vermicomposting	✓	✓		✓	✓	✓		✓			✓	✓		✓
		Phytoremediation	✓	✓										✓		✓

Source: Robbins (2001).

Anaerobic Digestion as a Future Technology for Liquid Manure Disposal

According to the Graver (Undated), anaerobic digestion system is beneficial through;

- Reduced odour, fly egg, weeds seed in digested manure.
- Reduced pathogens of land applied manure.
- Reduced methane emissions, a greenhouse gas
- Revenue :
    - on farm power production sale
    - tipping fees from other feed stocks
- Rural electricity grid voltage support
- Reduced dependence on foreign fossil fuel

Hog Manure Applied to Pasture and Forage

Hog manure can be used in the production of pasture and forage, this practice is mutually beneficial to the hog industry and the cattle industry. There is evidence in the literature that hog manure is economically beneficial to the cattle industry. The following is some literature evidence done by others in this field;

Brown (2007) did research on manure application to forage as an economical alternative. Brown writes, “Manure can provide both a yield and quality benefit compared to commercial K or no application, according to an Oxford Soil & Crop Improvement Association trial”. During the summer of 2006, manure was applied after 2^{nd} or 3^{rd} cuts of hay or haylage (at rates between 2,000 and 4,500 gallons/acre) on 8 replicated sites. Manure applied to alfalfa-grass crops showed a 12% yield increase and a slight quality benefit.

Prairie Agricultural Machinery Institute (2001a), investigated the possible benefits of grassland injection of swine manure, a three-year study (1998-2000). It was conducted on three different grasses (crested wheatgrass, smooth brome/alfalfa, and Russian wild rye). PAMI, using the Greentrac manure injection machine which is manufactured in Ireland, injected liquid hog manure 3½ inches (9 cm) deep into mature grass stands. The coulter-type openers were arranged to inject the manure at a row spacing of 10 inches (25 cm). The liquid manure was hauled directly from the earthen manure storage to the various sites, where it was injected into crested wheatgrass (Englefeld, Sask.), smooth brome/alfalfa stands (Burr, Sask.) in the fall of 1997, and into a Russian wild rye stand (Lanigan, Sask.) in April 1998. Liquid hog manure was injected again at all sites in the fall of 1998 and 1999. The Saskatchewan Forage Council took grass samples just after heading was complete to determine yield per plot. Samples were also taken to determine crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and the nitrate content of the forage for each treatment. Seed yield was also determined each year for the crested wheatgrass site at Englefeld, Sask. The application of injected hog manure showed large forage yield increases for all treatments as all plots had higher yields compared to the control plots. Crested wheatgrass was most responsive to the manure in terms of percentage yield, with up to a 300% increase in forage yield over the control. Yield increases for the smooth brome/alfalfa and Russian wild rye averaged about 200% higher than the control.

Prairie Agricultural Machinery Institute (2001b) also reported on a research project that was done in Tisdale, Saskatchewan to study swine manure injection into alfalfa stands. Two alfalfa production sites (star city and Valparaiso) were injected, again using a Greentrac. The alfalfa was at seeding stage when injected in May 1998(year 1), and was injected again in May 1999(year 2). In year 3, the treatments where applied in the fall of 1999 using PAMI's modified low disturbance manure injector. At each location the swine manure was injected into 10ft by 100ft plots. Swine manure was injected to specific plots at an application rate if 3,300 gallons/acre all three years.

Other plots were injected at a rate of 6,700 gallons/acre in year 1 and 3 and at a rate of 13,300 gallons/acre. A small plot harvester was used to take harvest samples on two separate cutting dates. The results showed that the injection of swine manure into established stands of alfalfa increases the yields and protein when there is a nutrient deficiency. Phosphorus, potassium, and sulphur are growth limiting factors that can be corrected by the injection of liquid swine manure. If alfalfa has adequate nutrients for growth, the injection of swine manure may not result in a yield or quality increase and may infect result in yield decrease.

Adoption of New Technology

Canadian hog producers are increasingly adopting farm practices and technology aimed at reducing the risk related to manure storage and handling, while increasing the use of nutrient contained in manure. According to Statistics Canada (2003), in 2001 almost 16,900 farms had liquid manure storage systems such as open tanks, concrete enclosures and lagoons, which are systems predominantly associated with confined livestock such as hog production. A majority of farms with liquid manure has storage of more than 250 days; this reduces the need to apply manure in unstable conditions, and to facilitate the use of nutrients in the manure at a more favorable stage of the crop growth. There are different influencing factors to adopt manure technology.

Adoption of new technology is governed by a complex set of factors. At the same time producers are a heterogeneous group (as suggested by Fulton and Keyowski (1999) in the context of adoption of herbicide resistant canola), which must be kept in mind when addressing a decision to adopt a new technology such as the application of specialized seed. Each producer must decide if the change will meet the overall objective of the farm business[4]. Conceptually a number of demand determinants can be identified, although the obvious ones include the benefits received and cost of adoption (Hall and Khan 2003). In the case of producers, the benefits are simply the difference in profits when a firm shifts from an older technology to a newer one.

Profitability of a new technology is a strong factor in the adoption of a new technology (Schneider and Wagner 2006). For example, Swinton, Harsh and Ahmad (1996) have reported

4 A study by the PEI Agriculture, Fisheries and Aquaculture (2001) has reported that most farmers stressed that the goal of the adoption of new technology was to improve their efficiency or bottom line.

that in Michigan, farmers were overwhelmingly concerned about profitability and risks of adopting the new technologies in crop management. It was also reported that benefits from adoption were often expected and not realized. Payne (2003) found producers' age, farm type, and farm size as factors affecting their decision to adopt a given technology. However, with respect to farm size, evidence in the literature seems to be mixed, as Hategekimana and Trant (2002) found that adoption of genetically modified soybeans and corn was undertaken by both small farms as well as large ones. The skill level of producers can also be a factor that can be instrumental in their decision to adopt new technology. For example, in the context of precision farming, adoption of variable rate fertilizer application technology was determined by human capital and attitude towards risk, along with size and location of farm (El-Osta and Mishra, 2001). Farm size, proximity to a research station, type of soil, and weather conditions were also reported to be factors affecting adoption of conservation tillage in the Prairies (Davey and Furtan, 2008).

Different behavior regarding the adoption of a new technology may be as much a function of different opportunities and constraints as of differences in inherent characteristics or perceptions (Cramb 2003). In the context of coated fertilizer technology, it is believed that this factor may not be very important since the level of complexity of the new technology is about the same as the older one. For those technologies that require a higher initial capital investment, financial status of the producers and availability of credit may be important factors affecting the demand for a new technology.

Gedikoglu and McCann (2007) have also shown that off-farm income is an important factor in adopting technologies that require a large initial capital investment. However, as concerns coated fertilizer technology the initial capital required is minimal, since no special equipment is required for the application of coated fertilizer. Information needs of producers are different in different stages of the adoption process (Gwin and Lionberger 2007). Those who adopt early make heavy use of research and expert sources of knowledge. Late adopters rely more heavily on other farmers' experiences with the technology. On the basis of knowledge at a point in time, a perception about the technology is developed which may affect the decision to adopt (Kulshreshtha and Brown, 1993). The level of knowledge and source of this information affect the process particularly during the early stages of adoption (Jabbar et al. 1998). The source of information may also play a key role in the decision-making process. According to Barao (1992) on-farm demonstrations of new technology help producers decide in favor of adoption. In addition to improved economic returns from the adoption of new technology, two other factors related to agricultural policies need further consideration: One, the presence of agricultural subsidies, and Two, environmental regulations governing aspects directly or indirectly related to the technology to be adopted. Miller and Tolley (1989) suggest that market intervention such as price supports or fertilizer subsidies can lead to gains by speeding up adoption of new technologies. The National Institute of Standards and Technology (NIST, 2003) reports that public policy constraints such as environmental regulations and tax laws can be major factors in producers' decision to adopt a new technology.

Another important factor in determining new technology is the institutional constraints in the form of regulations. For example, some of the adoption of environmental enhancing technologies depends on the farm and its location in Canada because of the difference in provincial regulations and laws across the country. Examples of these regulations include: grants to build biogas systems in Ontario and Quebec; Quebec pays up to 70 per cent of the cost of installing a manure handling facility; and Ontario implemented an 11 cent per Kilowatts hour (kwh) pricing regime (14 cent per kwh for peak usage) for green electricity. This last offer by Ontario gives incentives for farmers to invest profitable in green electricity.

According to Clark (Undated), Fritz and Paul Klaesi's dairy near Cobden Ontario has adopted an anaerobic digester operation system that uses methane from manure pits to produce electricity. The heart of the generation system is the bio digester. A bio digester is like a standard liquid manure storage tank but has a balloon like rubber membrane fastened at the top. Manure is fed to the digester, and methane gas, is produced by the anaerobic system decomposition and fermentation process, is trapped in the balloon. This then powers internal combustion engine that drives an electrical generator. The system produce about 1 1/2 to 2 1/2 kilowatt-hours per cow per day in a well-fed dairy cows. The Klaesis have 280 head of livestock and can produce up to 450 kW-hours.

According to the PAMI (2001c), earthen storage is the most common type of manure storage in the prairies. The earthen storage is primarily used for storage but a small amount of digestion occurs in the storage. Earthen storage uses a variety of linings to seal the interior and prevent nutrients from migrating through the surrounding soil and into usable groundwater sources. Earthen storage uses covers that vary from sealed plastic style with or without supporting structure, to a roof like structure of metal or convectional building materials, or even a floating cover like chopped straw. The primary benefit of the cover is the control of odors. In addition to odor control the cover helps prevent rainwater from entering the storage, reducing volumes of the storage and, therefore, application costs. Nutrient loss is reduced; covered storage retains more nitrogen, thereby increasing the fertilizer value of the manure.

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