The Actual Cost of Food Systems on Roadway Infrastructure

Center for Transportation Research and Education

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LEOPOLD CENTER
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Institute for Transportation

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The Leopold Center for Sustainable Agriculture explores and cultivates alternatives that secure healthier people and landscapes in Iowa and the nation.

About CTRE

The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

About the Institute for Transportation

The mission of the Institute for Transportation (InTrans) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

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THE ACTUAL COST OF FOOD SYSTEMS ON ROADWAY INFRASTRUCTURE

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Funds for this project have been provided by the Leopold Center for Sustainable Agriculture. Established by the 1987 Iowa Groundwater Protection Act, the Leopold Center supports the development of profitable farming systems that conserve natural resources. More information about the Leopold Center is available on the web at: www.leopold.iastate.edu, or by phoning the Center at 515-294-3711.

NONTECHNICAL SUMMARY

Title: The Actual Cost of Food Systems on Roadway Infrastructure
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This project was designed to provide more insight into the infrastructure challenges of agricultural enterprises in Iowa and to also facilitate the understanding needed to implement broader energy-related policy and planning. This work will also provide farmers and farmer networks with the necessary resources to justify increased local and state investments in the local and regional food systems.

To help demonstrate the value of the project to farmers, this project sought to develop a systematic methodology for estimating the actual cost of moving food produce from farm to market, including these costs:

- Environment (carbon emissions and air quality)
- Infrastructure
- Energy (fuel)
- Congestion
- Safety
- User (tax payer)

This goal was accomplished during the project period. The research was able to estimate the external costs of moving food in the local, regional, and conventional food systems and its impact on roadway infrastructure.

The project found strong reasons why Iowa should invest more in the local food system, as it has the least impact on roadway infrastructure. The total revenue for transportation-related programs in the state is not enough to even keep up with the damage to pavements from the conventional and regional food system, much less the environmental impacts of these long distance hauls. In addition, a niche for local food systems exists in the urban counties, which is sustainable and can expand the economic base of the state, if pursued vigorously.

INTRODUCTION

This research was designed to provide more insight into the infrastructure challenges of agricultural enterprises in Iowa and to also facilitate the understanding needed to implement broader energy-related policy and planning. Specifically, this research effort focused on achieving the following objectives:

- Capitalize on current research efforts to develop a systematic methodology for estimating the actual cost of moving food produce from farm to market including: environment (carbon emissions and air quality); infrastructure; energy (fuel); congestion; safety; and user (tax payer) costs. Use data on the highway system (roads and bridges) from the Iowa Department of Transportation (DOT) to test the methodology.

- Estimate the impact of local, regional, and conventional food systems (using truck and vehicle size as a measure) on roadway infrastructure. Correlate impacts to road costs; then, develop comparisons using distance as a variable.

The impact of the local food system is estimated by using case studies in Story, Adams, and Taylor Counties. The regional and conventional food systems are estimated based on statewide food freight data. The impacts are correlated to external cost of the distribution of the food system, such as emissions, congestion, safety, and pavement deterioration costs.

Background

More than 30 years ago, numerous studies were conducted on U.S. energy use and policy triggered by the Organization of the Petroleum Exporting Countries (OPEC) oil embargo (Hendrickson 1996). Unfortunately, the findings, still today, signal dire consequences for the U.S. economy and the future of sustainable agriculture, especially. With gasoline and diesel prices skyrocketing with each conflict in the volatile Middle East and the concerns about long-term petroleum reserves, there is need to rethink overall energy expenditure on a national scale (Brodt 2007).

Oil accounts for 40 percent of all energy consumed in the U.S. and 97 percent of the energy used for transportation (EIA 2006). Virtually all of the processes in modern food systems are dependent on crude oil (Jones 2002).

The mechanization of agriculture following World War II (WWII) encouraged mono-cropping, which has severely reduced production diversity and seriously undermined local production of food (Pirog et al. 2001). As a result, we have a food map of the U.S. with the Midwest as the Corn Belt, the Western Plains are the wheat country (GRACE 2006), and California is the fresh fruits and vegetables center (accounting for about 90 percent of the fresh vegetables consumed in the U.S.) (Heller and Keoleian 2002).

This decentralization of food production plays to the economy of scale, which relies on cheap oil to transport food around the country from the farm to processing plants to packaging plants to storage depots and on to the final sale point. A classic example of this effect is in the fact that 90 percent of fresh vegetables come from the San Joaquin Valley of California. As a result, the average foodstuff in the U.S. travels an estimated 1,500 miles before being consumed (Heller and Keoleian 2002).

One study in the UK estimated that imports of food products and animal feed into the UK through all transportation modes amounted to more than 51 billion ton-miles, which required 422.72 million gallons of fuel and released into the environment 4.1 million tons of carbon dioxide emissions (Jones 2002).

John Hendrickson's comprehensive summary of energy research in the food system captures the un-sustainability of the contemporary (or conventional, as Pirog et al. 2001 terms it) food system in the ratio of energy outputs (calories) to energy inputs. For the U.S., we are expending 10 to 15 calories to get 1 calorie (Hendrickson 1996). This obviously varies depending on the mode of transportation, but the bottom line is that we are putting in way too much for too little.

This un-sustainability is further captured by the National Surface Transportation Infrastructure Financing Commission (NSTIFC) interim report observation that the key federal funding sources for transportation infrastructure can no longer keep pace with demand (NSTIFC 2008). Not only are we running out of fossil fuel to transport food, we are also running out of good roads to carry the food. The collapse of the I-35 Bridge in Minneapolis in 2008 drives home the point of this observation.

Stoeltje (2008) draws a stark comparison between food miles and roadway damage. Between 1969 and 1998, the mileage that food traveled from farm to fork increased from 1,346 miles to more than 2,500 miles. This food mileage is carried by large semi-trailers that each causes as much damage as 10,000 passenger cars. Food makes up a significant portion of roadway freight and the increase in truck freight (which will grow by 70 percent by the year 2020) (Peterson 2005) compounds the structural damage, congestion, carbon emissions, and compromised road safety—just to mention a few of the important issues with our transport system (Stoeltje 2008, Pirog et al. 2001).

If the current trends, such as long-term world economic, demographic, and productive growth; China and India playing leading roles in the world economy during the twenty-first century (Li 2007); and the global energy crisis, continue, there is a common assumption that total oil production will reach its peak in the near future. Global oil discovery has been decreasing every year since 1980 and the total oil production is projected to reduce in 2050 about 70 percent from its peak level (Li 2007). In light of these developments and the unsustainability of an energy-intensive food system, it makes sense to retrace our steps and go back to local food production.

Green (1978) (in Jones 2002) mooted the idea right after the OPEC oil embargo. He called it the proximity principle, where production processes are located near the consumer. This idea is highlighted in Jones (2002) and further expanded in Pirog et al. (2001). They both call for a return to the pre-industrialization type of agriculture, where priority is given to the development of local and regional food systems.

Jones (2002) suggests there is growing evidence of environmental benefits of localizing food production in terms of eliminating the need to transport food longer distances or reduce food miles, as in Pirog et al. (2001). Pirog and Rasmussen (2008), in an Iowa study by the Leopold Center, found that moving to a local food system would result in a reduction of carbon dioxide emissions by as much as 6.7 to 7.9 million pounds for producing locally 10 percent more than usual. This is in addition to reduction in congestion, increase in lifespan of our roads, as well as improvement in traffic safety.

In addition to reducing food miles and the attendant environmental benefits as a result, a local and regional food system will also minimize the stress on road infrastructure. Food transport in a local food system involves gasoline-powered trucks, vans, and passenger vehicles, while the regional food system is characterized by mid-sized trucks (Pirog et al. 2001). In terms of infrastructure degradation, roadway wear increases exponentially with axle weight (between the third and fourth power) (Small et al. 1989, Mulholland 2005), so heavy trucks, which is a characterization of the conventional food system, causes roadway damage to the tune of hundreds or thousands of light vehicles. Consequently, there is significant savings in moving to local and regional food systems that rely on lighter vehicles or trucks.

PROJECT DESIGN, METHODS, AND MATERIALS

Objective

This project capitalizes on current research efforts to develop a systematic methodology for estimating the actual cost of moving food produce from farm to market including: environment (carbon emissions and air quality); infrastructure; energy (fuel); congestion; safety; and user (tax payer) costs. This research estimates the impact of local, regional, and conventional food systems on road infrastructure. The impacts are correlated to the external cost of the distribution of the food system, such as emissions, congestion, safety, and pavement deterioration costs.

To calculate these costs, three pieces of data are necessary:

- The weight of the food being moved
- How far the food is being moved
- How the food is being moved

Strategy

For the purpose of this study, the research team defined:

- Local food system as a countywide system
- Regional food system as food produced and consumed in Iowa
- Conventional as food produced in other states and consumed in Iowa

Food Freight

To estimate the impact of local, regional, and conventional food systems, this study uses three different types of data to estimate food freight:

- Food freight data from the Commodity Flow Survey
- Local consumption data from the U.S. Food Market Estimator
- Local consumption data from fresh fruit and vegetable survey in select counties

Freight Data obtained from the Commodity Flow Survey for Agricultural Products

The Commodity Flow Survey (CFS) is designed to provide data on the flow of goods and materials by mode of transport (US Department of Transportation). The CFS is the primary source of data on domestic freight movements. The CFS has been conducted every five years since 1993. The most recent data is for 2007.

The CFS uses the Standard Classification of Transported Goods (SCTG) and is conducted by the U.S. Bureau of the Census with support from the U.S. Department of Transportation.

The SCTG was designed to provide analytically useful commodity groupings for users who are interested in an overview of transported goods. Specifically, each level of the SCTG covers the universe of transported goods, and each category in each level is mutually exclusive. The research team used the SCTG to classify the food among the freight of commodities. For the purpose of this research, we considered the following classifications:

- Animals and fish (live), which include live bovine animals, poultry, swine, and fish
- Cereal grains
- Agricultural products excluding animal feed
- Animal feed and products of animal origin
- Meat, fish, and seafood, and their preparations
- Milled grain products and preparations, and bakery products
- Other prepared foodstuffs, and fats and oils
- Fertilizers

Agricultural machineries/machine parts/vehicle parts and alcoholic beverages were not included. In addition, fuel oils, gasoline, and gas were not included, given we couldn't determine the percentage directly related to food production and distribution. The mixed freight classification was also excluded for the same reason.

The limitation of the CFS for this project is that it does not distinguish between food and non-food related freight. It does not track what is sold at farmers' markets around the country. Also, the origin and destination of commodities are aggregated as states, which make it impossible to track local food system distribution.

Local Consumption Data from the U.S Food Market Estimator for Fresh Fruits and Vegetables

The U.S. Food Market Estimator was used with the purpose of addressing the CFS data limitations. To compare the regional with the local food system, the research team focused on consumption data from the U.S. Food Market Estimator for the amount of fresh fruits and vegetables received by retailer by county in Iowa. Limiting the sample study for the comparison to only fresh fruits and vegetables provides a consistent way to compare among the food systems; in addition, fruits and vegetables are a health necessity and can be easily produced.

The U.S. Food Market Estimator is funded by the Leopold Center and developed by the Center for Transportation Research and Education (CTRE) at Iowa State University (ISU). The U.S. Food Market Estimator provides information for 204 food products, including various dairy and meat products, fruits, vegetables, and grains. It uses the U.S. Department of Agriculture-Economic Research Service (USDA-ERS) Food Availability Data System, an annual estimate of the amounts of 204 food items available at a per capita rate for human consumption in the U.S. This tool multiplies the national per capita rate by the county population estimate (from the U.S. Census) to determine the potential market for each food product at the county level.

The U.S Food Market Estimator data reflects an ideal situation of consumption rate per capita, based on the national average. It does not consider accessibility to food or grocery stores, or income, among other factors.

Local Consumption Data from Select Counties' Fresh Fruits and Vegetables Survey

The purpose of the fresh fruits and vegetables survey was to compare the impact of location, demographics, and access to a major highway on the local food system. Three counties were selected: Story (urban) in central Iowa and Adams and Taylor (rural) in southwest Iowa. The survey captured the amount of fresh fruits and vegetables received by retailers or restaurants weekly.

In Story County, the survey only included grocery stores. The response rate was 30 percent. In Adams County and Taylor County, the survey was conducted in grocery stores, as well as any place where people might come to buy food. The Adams and Taylor County survey was conducted by the ISU Extension Office located in Region 18 with a response rate of 100 percent.

The data gathered from the selected county survey was used to verify the U.S. Market Estimator data. Accounting for the absence of data from farmers' markets in these counties and adjusting for the poor response rate in Story County, the survey appeared to verify the results of the U.S. Market Estimator.

The limitation with this data is the poor response rate for the urban county. Also, information was missing on the amount of fresh fruits and vegetables that was locally grown and sold in the select counties.

Vehicle Miles Traveled: Local, Regional, and Conventional

The vehicle miles traveled (VMT) is the accumulation of the total miles driven on Iowa roads by all vehicles. The VMT in the local, regional, and conventional system were all accumulated on the primary, local, and secondary roads.

Primary roads are maintained by the Iowa DOT, secondary roads are maintained by the counties, and local roads are maintained by the cities and municipalities. The local food system impacts mainly the local and secondary roads. The regional system impacts mainly primary roads and secondary roads.

The main impact of the conventional system is on the primary roads. The road miles information was obtained from the Geographic Information Management Systems (GIMS) of the Iowa DOT. For analysis purposes, only truck VMT was used in this project.

Type of Vehicle

The impact on the transportation infrastructure is very much dependent on the type of vehicle used to move goods. While heavier vehicles are employed on cross-country distances, for local and regional, mid- to light-trucks are used to move shorter distances.

To classify the type of vehicle, the body type was determined considering the type of commodities being transported. In considering the CFS data, the research team relied on truck data supplied by the Federal Highway Administration (FHWA) as part of the Freight Analysis Framework (FAF), while for the fresh fruit and vegetable freight; the research team used the U.S. Census Bureau's Vehicle Inventory and Use Survey (VIUS)[1].

[1] The Vehicle Inventory and Use Survey is conducted every five years as part of the economic census. It provides data on the characteristics of the truck population nationwide. The VIUS produces national and state levels of the total number of trucks. This survey has been discontinued; the last survey was in 2002.

DATA ANALYSIS AND DISCUSSION

This section estimates the impact of local, regional, and conventional food systems on roadway infrastructure. In general, when we talk about the cost of the food distribution, the externalities are not taken into account. The “external costs” or “true cost” of the freight of food considered are: emission cost, crash cost, travel time cost, and pavement deterioration cost. These costs were computed using the Highway Economic Requirements System-State Version (HERS-ST).

HERS-ST is a program developed by the FHWA. It calculates the investment that would be required to achieve certain highway system performance levels (U.S. Department of Transportation, Federal Highway Administration 2005). In addition, the HERS-ST can be used to evaluate the highway system performance for different scenarios of investment levels over an overall analysis period, which is divided into equal-length funding periods. The default is four funding periods of five years each for an overall analysis period of 20 years. Additional funding periods can be defined if the user chooses.

The HERS-ST model uses benefit-cost analysis and methods to evaluate potential improvements. It estimates the benefits resulting from potential highway improvements: benefits to highway users (travel time, operating costs, and safety), benefits to highway agencies (reduced maintenance costs), and the benefit of reducing vehicle emissions. These costs are computed per 1,000 vehicle miles, by road classification type, and location (interstate, principal arterial/state highway, major arterial, or major collector, with both rural and urban for each road class).

There are five types HERS-ST analysis, which we briefly introduce in this section:

1. **Minimum Benefit-to-Cost Ratio (BCR) Run.** In this analysis, the user specifies a minimum BCR that a roadway improvement must meet before HERS-ST will implement it.

2. **Multiple Minimum BCR Runs.** Here, the user specifies a range of minimum BCRS. The HERS-ST analyzer will go through the minimum BCRs in the order the user specified (starting, ending, and increment value after each run) and pick the BCR with the most cost-effective improvements.

3. **Funding Constrained Run.** A funding constrained run requires the user to specify the amount of resources available for each funding period and the HERS-ST analyzer selects the improvements that will give the most cost benefits.

4. **Performance Constrained Run.** Here the user specifies performance goals or can choose to use current conditions as the benchmark.

5. **Full Needs Run.** The full engineering needs run is an unconstrained (either by funding or by performance) analysis that only requires the user to set a deficiency level below which the analyzer selects improvements. This is a perfect case scenario, whereby all roads in need of improvements are actually improved.

For this project, the research team used the full engineering needs analysis of the infrastructure to estimate the costs of the externalities. Under the full engineering needs, the user only needs to define the deficiency level. The deficiency level is based on eight characteristics of the roadway: pavement condition, surface type, traffic volume/capacity (V/C) ration, lane width, right shoulder width, shoulder type, horizontal alignment, and vertical alignment.

If the deficiency level for a particular characteristic of a section is below the threshold, HERS-ST will analyze the BCR of potential improvements required to correct this condition. If the BCR is high enough, it may be selected to be implemented. In a full engineering needs analysis, improvements are selected based on engineering criteria and not on BCR, so, as a result, every section below the preset deficiency level is selected to be improved.

The research team, in choosing this analysis, understands that the costs estimated are the most conservative and represent the minimum costs for a network operating at a uniform level of service. In the light of budget cuts and recession, no transportation agency will be able to afford to keep all parts of the network running at the same level of service.

Conventional Food System

The conventional food system is largely based on the availability of fossil fuels necessary for mechanized agriculture, processing, and packaging of food products, as well as distribution. In addition, the need to trim down production costs in an expanding global market has led to the production of foods moved to areas where economic costs are lower or environmental regulations are not enforced, which are areas usually farther from the consumer markets.

To arrive at the external costs, the freight was broken down into truckloads to calculate the VMT. Because the total freight is a mixed bag of produce and finished products, the research team used the average of the payloads of the common types of vehicles employed in moving freight in the conventional system as shown in Table 1.

Table 1: Average Cargo Payload in the Conventional System

Commodity	Tractor-Trailer Type	Weight of Cargo (tons)
Field crop	Hopper	22.7
Meat or poultry, fresh or chill	Refrigerated Van	21.2
Dairy products	Refrigerated Van	18.9
Grain mill products	Van	20.5
	Hopper	23.7
Misc food preparations	Refrigerated Van	16.6
Average Cargo Payload		**20.6**

Source: Monsere 2001

The weights in Table 1 are based on the Iowa Truck Survey and Vehicle Inventory and Use Survey (Monsere 2001). The average truck load used for estimating the conventional food system was 20.6 tons. To be consistent, the research team assumed each truck had one full load and an empty load on the return trip. In estimating the VMT, the research team ignored the mileage of roadways already logged by these trucks outside of Iowa.

Between 2002 and 2008, the total freight moved by trucks in Iowa increased by 15 percent, while food freight increased by 5 percent, as shown in Table 2. These numbers are projected to almost double by 2035 (See Table 2).

Table 2: Conventional System Annual Freight and Shipment Value

	2002		2008		2035	
Freight	**Trucks Annually**	**$ Shipment (M Dol)**	**Trucks Annually**	**$ Shipment (M Dol)**	**Trucks Annually**	**$ Shipment (M Dol)**
Total	6,561,236	$132,367	7,391,336	$164,852	14,487,963	$279,184
Food	3,178,359	$30,888	3,315,683	$35,091	6,030,862	$26,863

Table 3 captures the external costs of moving all freight, as well as food freight, in Iowa between 2002 and 2008 for the conventional food system as calculated using HERS-ST. As previously defined, the conventional food system for the purpose of this study is where the origin of the produce is outside of Iowa and the destination is Iowa.

Table 3: External Cost of the Conventional System in Iowa

		2002	2008
Emission	**Total Freight**	$4,122,583,038	$4,707,981,021
	Food Freight	$1,997,039,761	$2,111,955,473
Crash	**Total Freight**	$21,587,668,688	$25,212,118,881
	Food Freight	$10,457,383,716	$11,309,916,549
Travel Time	**Total Freight**	$162,657,130,385	$177,254,290,115
	Food Freight	$78,793,502,494	$79,514,587,357
Pavement Maintenance	**Total Freight**	$1,862,608,246,496	$2,098,257,686,230
	Food Freight	$902,274,786,040	$941,258,425,856
Total External Cost	**Total Freight**	$2,050,975,628,607	$2,305,432,076,247
	Food Freight	$993,522,712,012	$1,034,194,885,236

Because the CFS only captures the origin and destination of the produce, it does not capture the numerous trucks that pass through the state on their way to the east or west coasts. However, it does capture instances where the origin of the produce is Iowa and the destination is outside Iowa.

In 2002, the total external cost to move food-related freight was almost $1 trillion and in 2008, that cost rose to more than $1 trillion, an increase of $25 billion. From Table 2, the total freight to be moved is estimated to increase by nearly double both the number of trucks by 2035 and, most likely, the costs to the state.

To put the numbers into perspective, in fiscal year (FY) 2002, total revenue for the Iowa Road Use Fund was $1.036 billion, while for FY 2008, it was $1.137 billion. The Road Use Fund is comprised of revenue sources, which include taxes on fuels; fees collected on vehicle registrations, titles, and driver licenses; and use tax collected on motor vehicle purchases and related equipment. Hence, Iowa is not collecting enough revenue to keep up with the demands on the network. From Table 4, each truck hauling food on the conventional food system costs the state $311,910 per year.

Table 4: External Cost Per Vehicle within the Conventional System in Iowa

		Total Freight	Food Freight
2002	**Total External Cost**	$2,050,975,628,607	$993,522,712,012
	Vehicles	6,561,236	3,178,359
	Cost Per Vehicle	$312,590	$312,590
2008	**Total External Cost**	$ 2,305,432,076,247	$1,034,194,885,236
	Vehicles	7,391,336	3,315,683
	Cost Per Vehicle	$311,910	$311,910

Regional Food System

The regional system, as previously defined, is where the origin of the produce is in Iowa and the destination is Iowa. The regional food system is typically used to capture food production and distribution within a metropolis or a state. In this research, it is used to capture food distribution within the state, basically moving food from one part of the state to another. It is a compromise between local and conventional food systems; the big difference from the conventional is that it keeps all sales proceeds within the state.

In this section, the research team looked at the regional food system in two parts, first using data from the CFS and then using data from the U.S. Food Market Estimator. Like the conventional system, the estimation of the external costs of the regional system is based on the HERS-ST.

CFS

The study demonstrates that, between 2002 and 2008, the total freight of commodities in the regional system increased 16 percent and the freight of food increased five percent as shown in Table 5.

Table 5: Regional System Annual Freight and Shipment Value

	2002		2008		2035	
Freight	Trucks Annually	$ Shipment (M Dol)	Trucks Annually	$ Shipment (M Dol)	Trucks Annually	$ Shipment (M Dol)
Total	7,987,816	$42,096	9,362,383	$55,420	14,807,203	$84,912
Food	4,114,680	$13,511	4,336,508	$15,307	7,433,210	$23,217

Within the regional system, the food freight is about 49 percent of the total freight of commodities in Iowa. Comparing Tables 2 and 5 reveals that the regional freight is greater than the conventional freight. This appears to be the case because the CFS has no way of tracking the numerous trucks that pass through the state on Interstate 80 to the east or west coasts.

The average payload used for estimating the regional food system was 20.6 tons (See Table 1). From Table 5, the total value of the freight attributed to the regional food system surpassed $13 billion and $15 billion in 2002 and 2008, respectively, at the expense of nearly $1.3 trillion in external costs for 2002 and more than that in 2008, as shown in Table 6.

Table 6: External Cost of the Regional System in Iowa

		2002	2008
Emissions	**Total Freight**	$5,018,937,471	$5,963,457,689
	Food Freight	$2,585,352,603	$2,762,179,474
Crashes	**Total Freight**	$26,281,377,066	$31,935,431,242
	Food Freight	$13,538,050,036	$14,791,987,683
Travel Time	**Total Freight**	$198,022,928,635	$224,522,667,886
	Food Freight	$102,005,473,665	$103,995,355,902
Pavement Maintenance	**Total Freight**	$2,267,586,665,257	$2,657,799,781,988
	Food Freight	$1,168,078,128,431	$1,231,050,908,347
Total External Cost	**Total Freight**	$2,496,909,908,429	$2,920,221,338,805
	Food Freight	$1,286,207,004,735	$1,352,600,431,407

As previously shown for the conventional system, the state does not collect enough revenue and, for argument sake, the amount is not even enough for just pavement maintenance. The cost per vehicle in Table 7 for regional is equal to the cost for the conventional system, because the research team did not take into consideration the VMT outside of Iowa in estimating the external costs due to the conventional system. These costs are estimated to nearly double by 2035, going by the estimate that the total freight is to increase by nearly 50 percent.

Table 7: External Cost Per Vehicle within the Regional System in Iowa

Regional		Total Freight	Food Freight
2002	**Total External Cost**	$2,496,909,908,429	$1,286,207,004,735
	Vehicles	7,987,816	4,114,680
	Cost Per Vehicle	$312,590	$312,590
2008	**Total External Cost**	$2,920,221,338,805	$1,352,600,431,407
	Vehicles	9,362,383	4,336,508
	Cost Per Vehicle	$311,910	$311,910

U.S Food Market Estimator

In addition, the research team considered fresh fruit and vegetable freight based on 2008 data from the U.S. Food Market Estimator. The research team's focus on fresh fruits and vegetables seemed obvious, given these are perishable food items that require a faster mode of transportation. Also, fresh produce is essential to any healthy diet or lifestyle and any talk about local food will not be complete without fresh fruits and vegetables.

To calculate the VMT, the team considered two trips per truck, four times per week, for truck deliveries of fresh fruits and vegetables to retail stores. This was based on consultation with some of the retailers in the state. And, the tractor-trailer type for the transportation of fresh fruits and vegetables considered was the refrigerated truck with a payload of 16.6 tons (Monsere 2001, as shown in Table 1).

The freight of fresh fruits and vegetables in the regional food system accounts for 219,648 trucks annually. Table 8 shows the external costs (using the HERS-ST rates) of moving fresh fruits and vegetables annually in the state, which comes to more than $68 billion. From Table 9, this equates to paying $76 for a pound of fresh fruits and vegetables.

Table 8: External Cost of Fresh Fruits and Vegetables within the Regional System in Iowa

External Cost	2008
Emissions	$139,906,857
Crashes	$749,227,387
Travel Time	$5,267,457,658
Pavement Maintenance	$62,353,827,994
Total External Cost	$68,510,419,896

Table 9: External Cost Per Pound of Fresh Fruits and Vegetables within the Regional System

		Fresh Fruits and Vegetables Freight
2008	Total External Cost	$68,510,419,896
	Vehicles	219,648
	Cost Per Pound	$76

Local Food System

For this research, the local food system is defined as a county-wide system. Conceptually, the local food system is used to capture the scenario where the farmers and the consumers are able to interact face-to-face. It virtually minimizes, if not eliminates, the use of big trucks in food distribution. Because the food travels very short distances, it also eliminates waste during distribution and delivers fresh produce to consumers. Supporters of the local food system advocate that local food production, processing, distribution, and consumption is integrated to enhance the economic, environmental, and social health of a particular place (Garrett and Feenstra 1999).

The research team focused on the freight of fresh fruits and vegetables in three Iowa counties with very different accessibility to fresh food: Story, Adams, and Taylor. Story County was selected because of its urban influence, especially Ames, which has several diverse grocery store opportunities for consumers. In contrast, Adams and Taylor Counties, are mainly rural, far removed from the Interstate or major highways. Adams and Taylor Counties have only three grocery stores, which implies that consumers need to travel more to get fresh fruits and vegetables, unless they grow their own.

The research team looked at two sources for data on fresh fruit and vegetable distribution in the state. The first part was from the U.S. Food Market Estimator and the second part was based on the survey of the total fruit and vegetable deliveries received by retailers in the selected counties.

U.S. Food Market Estimator

The U.S. Food Market Estimator provides data consumption per county based on the national consumption rate, per capita. The amount of fresh fruits and vegetables received by retailer was considered in Story, Adams, and Taylor Counties. For the distribution patterns of truck-fresh fruit and vegetable deliveries to retail stores, two trips were considered per truck, four times per week, in Story County, while, for Adams and Taylor Counties, the team used one delivery per week. Table 10 shows the resulting number of trucks for moving fresh fruits and vegetables annually in the counties, assuming the tractor-trailer type considered is refrigerated van cargo of 16.6 tons (Monsere 2001).

Table 10: Local System Annual Fresh Fruit and Vegetable Freight using U.S. Market Estimator

County	Trucks Annually (Cargo 16.6 Ton)
Story	6,656
Adams	104
Taylor	156

The external costs of fresh fruit and vegetable freight for the local food system, as shown in Table 11, were computed by the HERS-ST based on the 2008 consumption data from the U.S. Market Estimator.

Table 11: 2008 External Costs of Fresh Fruits and Vegetables Freight

	Story County	Adams County	Taylor County
Emission	$53,811.36	$349.81	$573.51
Crash	$270,070.46	$1,918.00	$3,076.69
Travel Time	$1,848,121.18	$13,609.54	$21,645.91
Pavement Maintenance	$22,859,041.74	$158,678.86	$255,940.35
Total External Cost	$25,031,044.75	$174,556.20	$281,236.47

In Table 12, the research team shows that the cost per pound for moving fresh fruits and vegetables in Story, Adams, and Taylor Counties in the local system is $0.97, $0.14, and $0.14, respectively. This represents a huge drop from the cost per pound in the regional food system.

Table 12: External Cost Per Vehicle and Per Pound of Fresh Fruits and Vegetables within the Local System

2008		Fresh Fruits and Vegetables Freight
Story County	Total External Cost	$25,031,045
	Vehicles	6656
	Cost Per Vehicle	$3,761
	Cost Per Pound	$0.97
Adams County	Total External Cost	$174,556
	Vehicles	104
	Cost Per Vehicle	$1,678
	Cost Per Pound	$0.14
Taylor County	Total External Cost	$281,236
	Vehicles	156
	Cost Per Vehicle	$1,803
	Cost Per Pound	$0.14

Selected County Survey

In addition, a survey of the fresh fruit and vegetable freight received by retailers was conducted in the three counties. In Story County, the research team did a phone interview with the store managers of all grocery stores, while in Adams and Taylor Counties, the ISU Extension in Region 18 carried out the survey.

The data collected for Story County was estimated at about 30 percent of the total fruits and vegetables received by retailers, as some grocery stores refused to disclose their fruit and vegetable freight. In Adams and Taylor Counties, the data collected captures 100 percent of the fruits and vegetables received by retailers. However, fruits and vegetables sold by farmer's markets or roadside vendors were not included in the data.

In Story County, 10 grocery stores were surveyed (See Appendix B). The stores were asked about the amount of fresh fruits and vegetables they receive per week and how many times per week they receive trucks deliveries. Four of the 10 stores provided information and two of those provided data about the frequency of truck deliveries. For the purpose of this research, the team considered four times per week as the average for store deliveries in Story County.

For the grocery stores that did not respond to the survey, the research team estimated the amount, based on observation and comparison of square footage of the fresh fruit and vegetable aisles between the groceries stores that responded and those that did not.

For the rural counties surveyed, Adams County receives 8,595 pounds per week of fresh fruits and vegetables (See Appendix B) with a frequency of two trucks each week. Adams County has only one grocery store, which was surveyed. In addition, 18 restaurants and the local schools were surveyed. All of the establishments surveyed receive truck deliveries once a week. For the purpose of estimating the external costs, the research team assumed that the truck delivering to the grocery store was not the same one delivering to the restaurants and schools (See Table 13).

Table 13: Local System Freight Comparison between U.S. Food Market Estimator and County Survey

		U.S Market Estimator	Survey
Trucks Weekly (Cargo 16.6 Ton)	Story County	128	120
	Adams County	2	2
	Taylor County	3	2
Trucks Annually (Cargo 16.6 Ton)	Story County	6656	6240
	Adams County	104	104
	Taylor County	156	104

In Taylor County, 9,155 pounds per week of fresh fruits and vegetables are received each week (See Appendix B). The survey includes: grocery stores, restaurants, schools, and nursing homes. The grocery stores are supplied by two trucks weekly while all the other establishments surveyed receive truck deliveries once a week (See Table 13).

In Taylor and Adams Counties, the survey includes 100 percent of fresh fruits and vegetables received by retailers. Thus, the consumption rate per capita in those counties is lower than the national average, which is six pounds per week (See Table 14). However, the estimates did not include what was locally grown (and the same is true for Story County).

Table 14: Fruit and Vegetable Consumption Rate Per Capita from County Survey

	Fruit and Vegetable Consumption Pounds Weekly		
County	**Population**	**Consumption**	**Consumption Per Capita**
Story	86,754	450,562	5.19
Adams	4,482	8,595	1.92
Taylor	6,958	9,155	1.32

Sensitivity Analysis

A sensitivity analysis was conducted to test the impacts of increasing the local and regional food systems for fresh fruits and vegetables. Three different types of vehicles/trucks were tested for these two food systems.

- **Vehicle/Truck types**:

    1. Light Duty/5 ton truckload
    2. Medium Duty/9.75 ton truckload
    3. Heavy Duty/16.6 ton truckload

- **Food Systems:**

    1. Local:
        - Story County
        - Adams County
        - Taylor County
    2. Regional:
        - Iowa (statewide)

Table 15 captures the summary of the sensitivity analysis and the dollar amount of external costs alone that will be saved by minimizing the distance food travels. The sensitivity analysis is based on the external costs (emissions, crashes, travel time, and pavement deterioration) of the transportation of fresh fruits and vegetables from farm to retailer.

Table 15: Sensitivity Analysis for the Local and Regional Food Systems

County	Truck Class	F&V Total External Cost	Waste Total External Cost	Total External Cost (F&V + Waste)	Vehicles	Cost Per Vehicle
Story	Light Truck 5 ton	**$4,963,429**	**$37,286**	$5,000,716	21,632	$231
	Medium Truck 9.75ton	**$8,737,169**	**$62,510**	$8,799,679	11,648	$755
	Heavy Truck 16.6ton		**$182,730**	$25,031,045	6,240	
Adams	Light Truck 5 ton	**$27,392**	**$884**	$28,276	260	$109
	Medium Truck 9.75ton	**$52,297**	**$1,443**	$53,740	156	$344
	Heavy Truck 16.6ton	**$170,413**	**$4,144**	$174,556	104	$1,678
Taylor	Light Truck 5 ton	**$46,534**	**$1,458**	$47,992	416	$115
	Medium Truck 9.75ton	**$74,510**	**$2,394**	$76,904	208	$370
	Heavy Truck 16.6ton	**$274,333**	**$6,904**	$281,236	156	$1,803
State-wide	Light Truck 5 ton	**$14,381,761,833**	**$111,687,369**	$14,493,449,202	725,504	$19,977
	Medium Truck 9.75ton	**$23,674,119,469**	**$183,514,194**	$23,857,633,664	372,736	$64,007
	Heavy Truck 16.6ton	**$68,510,419,896**	**$529,325,810**	$69,039,745,706	219,648	$314,320

All values are annual
F&V = Fruits and Vegetables

The Vehicle column in Table 15 is the number of trucks it will take if the total weight of fresh fruits and vegetables consumed within the counties and state-wide, as estimated from the U.S. Market Estimator, is moved by the three types of truck categories.

The Fruits and Vegetables (F&V) Total External Cost is the resulting external costs from the three types of trucks, arranged by the individual counties and statewide. In addition, because of the distance between farm and table, a significant portion of the produce is lost or wasted, which is captured in the Waste Total External Cost column.

The transportation waste was estimated as the difference between the farm weight and retail weight.

The USDA/Economic Research Service provided the retail and farm weight per capita (for fresh fruit and vegetable annual consumption) for the U.S. and the research team used that to estimate the weight of fresh fruits and vegetables that did not make it to the retailer. The estimate weight for waste was broken into the appropriate truck count and HERS-ST was used to estimate the external costs. Hence, if local food systems are developed, the waste is going to be transformed to reductions in the external costs.

The sensitivity analysis demonstrates that the local food system, with the use of light-duty trucks, will save almost three times more money in transportation than the regional or conventional food system, using medium- and heavy-duty trucks. The waste due to the transportation costs the state more than $500 million in external costs annually.

In addition, the sensitivity analysis makes obvious that heavy-duty trucks have higher external cost than medium- and light-duty vehicle trucks. Therefore, between 12 and 18 percent is saved from the external cost per vehicle when light-duty trucks are used.

CONCLUSIONS

This research study investigated the impacts of the conventional, regional, and local food systems on the roadway infrastructure. This was done by analyzing data that provided information on the vehicle miles traveled (VMT) in moving food from farm to table, types of vehicles used, and the weight of food moved.

Food freight increased five percent between 2002 and 2008. It is expected to increase more than 80 percent by 2035. Understandably, the external costs are expected to increase proportionally with the freight increase. The external costs of moving food on the conventional and regional food systems far surpasses the total revenue the state brings in for transportation-related programs, so much that, at the current levels, it cannot even support pavement maintenances.

From the available data, the regional food system moves more freight in terms of weight than the conventional, due to the fact that data did not track the freight that passes through the state. In any case, encouraging the development of a regional food system will not do much to change the food freight trend. Currently, the cost for moving fresh fruits and vegetables within Iowa comes to a staggering $76 per pound. This price tag is not accounted for when the consumer checks out at the grocery stores.

The case for a local food system is much about reducing the distance food travels, which makes it feasible to move the food with a lighter-weight vehicle that has negligible impact on the pavement, compared to the semi-trailers that dominate the state’s highways.

The study of local food systems for the three counties (Story, Adams, and Taylor) demonstrates that areas remote from a major highway and with a low population density are more likely to develop local food systems to supply their demand. Having the big grocery stores represented in these remote areas is not feasible given it will be difficult to generate enough VMT, because of the relatively small demand to make it economically viable.

In the local food system in Adams and Taylor Counties, the farmers' markets and roadside vendors are important to meet the fresh fruit and vegetable demand in the rural counties. In contrast, Story County has the benefit of being close to a major highway and the Interstate system for supplying their demand of fresh fruits and vegetables. Therefore, in more urban counties, like Story County, making a case for local food will depend strongly on making a case given the external costs of transportation.

With local food systems, the external costs of transportation are very low compared to the regional and conventional food systems.

In addition, dependence on the conventional food system has a stark disadvantage for the urban areas, as it tends to create food deserts when one group is cut off, disadvantaged by income or access to public transportation. On the other hand, developing a local food system close to the urban counties does have huge economic benefits for the state, as more and more people are beginning to question where their food comes from, and other studies have shown that consumers are willing to pay more for locally-grown fruits and vegetables.

IMPACTS OF THE RESULTS

As proposed, the research team was able to estimate the external costs associated with local, regional, and conventional food systems on the roadway infrastructure. Based on the data available, using distance as a variable was not feasible, but the project presents the unsustainability of the conventional and regional food systems and provides adequate information and background to begin a serious policy discussion on road-use costs in the state.

This is information that can be used by the farmers and farmers' networks, consumers, media, policymakers, and the food industry, including producer associations, processors, and food services companies, as well as academia, to provide constructive feedback as the policy discussion unfolds.

In addition, the findings of this project benefits agriculture in the state as it places Iowa farmers in the spotlight, not just for its grains, this time, which is powering the bio-economy in the nation, but for the benefits that the state would accrue if Iowa agriculture were diversified with a view toward creating and sustaining the local food system across Iowa.

OUTREACH AND INFORMATION TRANSFER

Publications

The final report and a technology transfer summary were produced for this project.

Education and Outreach

1. The project was presented at a session of the 2009 Mid-Continent Transportation Research Symposium, August 20 and 21, 2009. The symposium, as a whole, attracted more than 270 people from transportation agencies in the Midwest and around the country; 25 to 35 people attended this session.

2. At the Leopold Center Marketing and Food Systems Initiative and Value Chain Partnerships Workshop, April 1, 2010, the workshop attracted at least 250 people from six states and about 30 to 40 attended this session. More than 15 minutes were spent on the question and answer session following the presentation, which highlights the interest level of the project as a policy tool.

Cooperative Efforts and Student Support

1. The roadway data was from the Geographic Information Management System (GIMS) of the Iowa DOT.

2. ISU Extension in Region 18 carried out the survey of Adams and Taylor Counties with 100 percent participation.

3. Professor Marwan Ghandour from the Department of Architecture at ISU was Co-PI on the project.

4. One student was funded quarter time on the project.

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LEVERAGED FUNDS

The Leopold Center provided all funding for this project; no funds were leveraged.

EVALUATION

No formal project evaluations were conducted on this project.

BUDGET REPORT

This was a one year project request, with a subsequent six-month extension. The total request was $24,923 and total expenditures were $24,923. Expenditures during the first year were $22,923 and expenditures during the six-month extension were $2,000. The primary expenditures for this grant were salaries and fringe. No other additional sources of funding were provided for this project.

APPENDIX A. COMMODITY FLOW SURVEY

Table A.1: Food Freight in the Conventional System

Origin and Destination	Commodity	Mode	K Ton. 2002	2008	2035
Other States to Iowa	Animal feed	Truck	2,681	2,798	8,223
	Cereal grains	Truck	16,232	16,820	35,714
	Fertilizers	Truck	602	751	4,861
	Live animals/fish	Truck	1,448	1,509	1307,
	Meat/seafood	Truck	1,094	1,150	2,497
	Milled grain prods.	Truck	1,240	1,300	3,641
	Other ag prods.	Truck	4,667	4,871	4,835
	Other foodstuffs	Truck	2,277	2,526	6,002
	Sub-Total	Truck	**30,242**	**31,724**	**67,080**
Iowa to Other States	Animal feed	Truck	4,021	4,133	6,567
	Cereal grains	Truck	11,140	11,668	21,119
	Fertilizers	Truck	3,170	3,289	258
	Live animals/fish	Truck	229	284	1,083
	Meat/seafood	Truck	3,175	3,233	4,356
	Milled grain prods.	Truck	1,120	1,179	260
	Other ag prods.	Truck	2,940	3,105	13,107
	Other foodstuffs	Truck	9,436	9,688	10,406
	Sub-Total	Truck	**35,232**	**36,579**	**57,156**
Conventional	**Total**	Truck	**65,474**	**68,303**	**124,236**

Table A.2: Food Freight in the Regional System

Origin and Destination	Commodity	Mode	K Ton.		
			2002	**2008**	**2035**
Iowa	Animal feed	Truck	10,801	11,159	20,190
	Cereal grains	Truck	49,885	51,746	99,576
	Fertilizers	Truck	8,832	9,298	3,443
	Live animals/fish	Truck	1,682	1,876	3,909
	Meat/seafood	Truck	766	930	1,328
	Milled grain prods.	Truck	551	732	165
	Other ag prods.	Truck	7,438	8,064	17,884
	Other foodstuffs	Truck	4,807	5,526	6,630
Regional	**Total**	Truck	**84,762**	**89,332**	**153,124**

APPENDIX B. COUNTY SURVEY

Table B.1: Story County Fresh Fruits and Vegetables Received by Retailer

	Retailer	Pounds of fruits and vegetables received by retailer per week	K Tons of fruits and vegetables received by retailer annually
Story County	Establishment 1	55,000	1.297
	Establishment 2	50,000	1.179
	Establishment 3	35,000	0.826
	Establishment 4*	62,000	1.462
	Establishment 5	4,180	0.099
	Establishment 6*	60,000	1.415
	Establishment 7*	61,000	1.439
	Establishment 8*	64,000	1.510
	Establishment 9*	3,382	0.080
	Establishment 10*	56,000	1.321
	Total	**450,562**	**11**

* Estimated values

Table B.2: Taylor County Fresh Fruits and Vegetables Received by Retailer

	Retailer	Pounds of fruits and vegetables received by retailer per week	K Tons of fruits and vegetables received by retailer annually
Taylor County	Establishment 1	4,500	0.1061
	Establishment 2	30	0.0007
	Establishment 3	505	0.0119
	Establishment 4	35	0.0008
	Establishment 5	45	0.0011
	Establishment 6	40	0.0009
	Establishment 7	20	0.0005
	Establishment 8	45	0.0011
	Establishment 9	10	0.0002
	Establishment 10	3,750	0.0885
	Establishment 11	30	0.0007
	Establishment 12	70	0.0017
	Establishment 13	25	0.0006
	Establishment 14	10	0.0002
	Establishment 15	40	0.001
	Establishment 16	0	0
	Establishment 17	0	0
	Total	**9,155**	**0.216**

Table B.3: Adams County Fresh Fruits and Vegetables Received by Retailer

	Retailer	Pounds of fruits and vegetables received by retailer per week	K Tons of fruits and vegetables received by retailer annually
Adams County	Establishment 1	7,325	0.1728
	Establishment 2	40	0.0009
	Establishment 3	125	0.0029
	Establishment 4	205	0.0048
	Establishment 5	105	0.0025
	Establishment 6	15	0.0004
	Establishment 7	95	0.0022
	Establishment 8	10	0.0002
	Establishment 9	50	0.0012
	Establishment 10	25	0.0006
	Establishment 11	60	0.0014
	Establishment 12	270	0.0064
	Establishment 13	105	0.0025
	Establishment 14	0	0.0000
	Establishment 15	5	0.0001
	Establishment 16	65	0.0015
	Establishment 17	0	0.0000
	Establishment 18	10	0.0002
	Establishment 19	85	0.0020
	Establishment 20	0	0
	Total	**8,595**	**0.203**

Note: Names of establishments are confidential.