Assessing the feasibility of Broiler Manure Transportation and Application in Crop Production under Environmental Restrictions

Keshav Bhattarai, Associate Professor, Central Missouri State University, Warrensburg, MO 64093, Email: bhattarai@cmsu1.cmsu.edu
Krishna P. Paudel, Assistant Professor, Louisiana State University Agricultural Center, Baton Rouge, LA 70803

Corresponding Author: Krishna P. Paudel
Department of Agricultural Economics and Agribusiness
Louisiana State University
Baton Rouge, LA 70803
Phone: 225-578-7363
Fax: 225-578-2716
Email: kpaudel@agcenter.lsu.edu

Preliminary Draft, Please Do Not Quote

Selected Paper prepared for presentation at the
Southern Agricultural Economics Association Annual Meetings
Orlando, Florida, February 5-8, 2006

Assessing the Feasibility of Broiler Manure Transportation and Application in Crop Production under Environmental Restrictions

Abstract

This study combines survey information and GIS based optimization model to identify the optimal distribution of broiler litter in crop production. The results obtained provide more plausible transportation routes than the method that does not utilize all these constraints.

Assessing the Feasibility of Broiler Manure Transportation and Application in Crop Production under Environmental Restrictions

Broiler production significantly contributes to the agricultural revenue in Southern U.S. states. This is no exception for Louisiana where more than billion dollars in revenue are generated from broiler production. Broiler production is a unique operation than other livestock industries as it is a vertically integrated industry where farmers are merely contractors. Farmers own broiler house and provide labor and management where as an integrator provides medicines, feed and chicks. Unfortunately, the responsibilities for waste management lies completely on broiler producers creating a unique scenario uncommon on many crop production contractual agreement where every thing (input/output) is proportionately divided. One of the common uses for broiler litter is to apply it on land as crop nutrients. The transportation and use of broiler litter from production facilities to crop land costs money, therefore, breakeven distance depends on nutrient content in litter as well as litter hauling, loading, and spreading costs. In addition to those, litter cannot be applied just any where because of unique crop needs and environmental restrictions associated with litter use. Therefore, it is imperative to combine survey information on broiler litter use to GIS model to obtain a better optimization model. This study advances previous studies by embracing a comprehensive approach in litter transportation and use based on spatial characteristics of land.

The objectives of this study are:

i) To describe the manure utilization pattern of broiler farms located in Northern Louisiana

ii) To combine litter related information to develop a GIS based spatial optimization model under soil, water and crop nutrient restrictions

Data and Methods

The study area comprises of 12 Parishes of Louisiana (Figure 1, Table 1). Data were collected from a mail survey sent to all broiler producers in Louisiana following the tailored designed method (Dillman, 2001). The survey contained three sections: Broiler manure production and use, BMP adoption, and Demographic and farm related characteristics. Surveys were mailed first on May 2004 and then follow-up surveys were mailed after three weeks. After two weeks of mailing the initial round of survey, a reminder post card was mailed to each individual who did not respond within that period. Louisiana Department of Agricultural Statistics helped to compile the list of broiler producers and mailing of the surveys to farmers. Surveys were received at a response rate of 24.9%.

Descriptive analyses related to broiler farm and broiler litter uses were conducted. The information obtained from descriptive analyses is then combined with GIS based optimization model to develop cost effective transportation routes for manure utilization (Table 2).

One of the most common methods used in GIS in transportation modeling is the least-cost path, which becomes a vehicle's guide between the origin and destination. The least-cost path is generated through an exhaustive and iterative process indicating the cost value to the nearest source cell for each grid cell and an allocation surface showing source catchments. Not only the least-cost path takes into account of distances but also it incorporates various bio-geo- and socioeconomic factors to represent the landscape reality, such as roads, elevation, land use, and soils, to name a few.

Results

Results indicated that on average farmers kept 453,000 broilers in 2003 in 6 new and retrofitted broiler houses. Only 10.71% of respondents had less than 100,000 broilers in their production operation. Farmers have owned and rented land for their operation and in average used 50% of total land for broiler litter disposal purpose. To dispose of the broiler litter produced farmers have used both cake out and wind row options. Some of the farmers had chosen the option of exchanging litter produced in broiler houses with rice hulls. Litter is also commonly scraped off and loaded into spreader for dispersal. Litter produced is also piled up and spread by themselves or hired some one to apply litter on crop and pasture land that the farmers own or sell the litter to other farmers. Some of these farmers also give away the litter produced and even haul litter because they feel they are getting free disposal land. There are various arrangements of litter use.

Those farmers who said they do not sell litter have given few reasons. Percentage of respondents feel that market is not available in that area to sell litter, percentage said they use litter produced in their farm to apply on their own land (crop or pasture land) hence do not sell it, and others use bartering system whereby some one cleans the broiler houses and the broiler operator gives away broiler litter free to those cleaning people.

Our optimization model is based on those farmers who sell their broiler litter and charge certain amount. Our survey indicated that farmers charge approximately $8 per ton of broiler litter when they sell it others. The loading cost per ton, spreading cost per acre and transportation costs per ton per mile were found to be $3.70, $2.36 and $1.32 respectively. These costs, especially the transportation cost, were significantly higher than the one we have seen in manure transportation literature. Still, we develop the optimization model based on these numbers. We developed a cost surface using ArcGIS 9.1 “plus” function which considers slope and aspect of the land, land use and land cover types. Further, road network, speed limit, land classification, and river miles within the region were considered and modeled using digital elevation model (DEM) and LIght Detection And Ranging (LIDAR) data. The integrated model with information of slopes on road travel speed, barriers, and possible additional delay times for vehicle deployment due to certain restriction applied to roads, refinement of off road travel speeds and refinement of on travel speeds with nitrogen and phosphorus consistent rules provided better map for litter transportation than the model which did not consider these restrictions.

Conclusions

Broiler production holds a key to an economic engine in many agricultural counties in Southeast USA. However, there are serious concerns related to the disposal of broiler litter produced in broiler farms. One of the ways to reduce nonpoint source pollution and hence continue producing broilers in the region is through land application of broiler litter with consideration of all environmental constraints. Combining GIS based spatial model with survey information provides more reliable map of minimum cost solution. Results obtained here should prove to be helpful in policy formulations related continuous broiler production and pollution reduction in broiler production regions.

Table 1: Biophysical Features of Study Parishes

SN	Parishes	Total Areas in acres	Areas in acres			Length Miles	
			Urban Area	Farm/Pasture	Water Bodies	Rivers	Roads
1	Bienville	523482	1462	35219	3924	160	468
2	Claiborne	491277	1565	40764	8150	166	341
3	Jackson	369583	1980	18600	6099	121	244
4	Lincoln	301860	17220	38704	414	159	404
5	Natchitoches	830088	7211	216130	29425	356	583
6	Ouachita	405915	50348	118328	15829	162	455
7	Sabine	649377	1199	45111	80615	153	315
8	Union	573683	1874	49426	16111	191	306
9	Vernon	868042	14356	65320	7188	231	368
10	Webster	393187	11115	57079	15994	165	421
11	Winn	610870	3754	18933	893	219	401
	Total	6017184	112084	703614	184592	2083	4306

Table 2. Broiler Litter Produced and Nutrient Equivalent in Study Parishes in Louisiana

Parish		Poultry farms	Number of Broilers	Total Litter (tons)	Production of N_2, P_2O_5, and K_2O nutrients in tons			Available N_2, P_2O_5, and K_2O nutrients in tons		
					N_2	P_2O_5	K_2O	N_2	P_2O_5	K_2O
1	Bienville	19	7210402	12120	374.52	363.61	241.19	281.19	272.71	181.80
2	Claiborne	49	20979217	35265	1089.69	1057.95	701.77	818.15	793.46	528.98
3	Jackson	44	18409422	30945	956.21	928.36	615.81	717.93	696.27	464.18
4	Lincoln	76	36641616	61593	1903.22	1847.78	1225.70	1428.95	1385.84	923.89
5	Natchitoches	26	13614001	22884	707.13	686.53	455.40	530.92	514.90	343.27
6	Ouachita	6	3592068	6038	186.58	181.14	120.16	140.08	135.86	90.57
7	Sabine	88	37576114	63164	1951.75	1894.91	1256.96	1465.39	1421.18	947.45
8	Union	165	70889469	119162	3682.10	3574.85	2371.32	2764.55	2681.14	1787.42
9	Vernon	10	3076000	5171	159.77	155.12	102.89	119.96	116.34	77.56
10	Webster	6	1425812	2397	74.06	71.90	47.69	55.60	53.93	35.95
11	Winn	2	836313	1406	43.44	42.17	27.98	32.61	31.63	21.09
	Total	491	214250434	360144	11128	10804	7167	8355	8103	5402

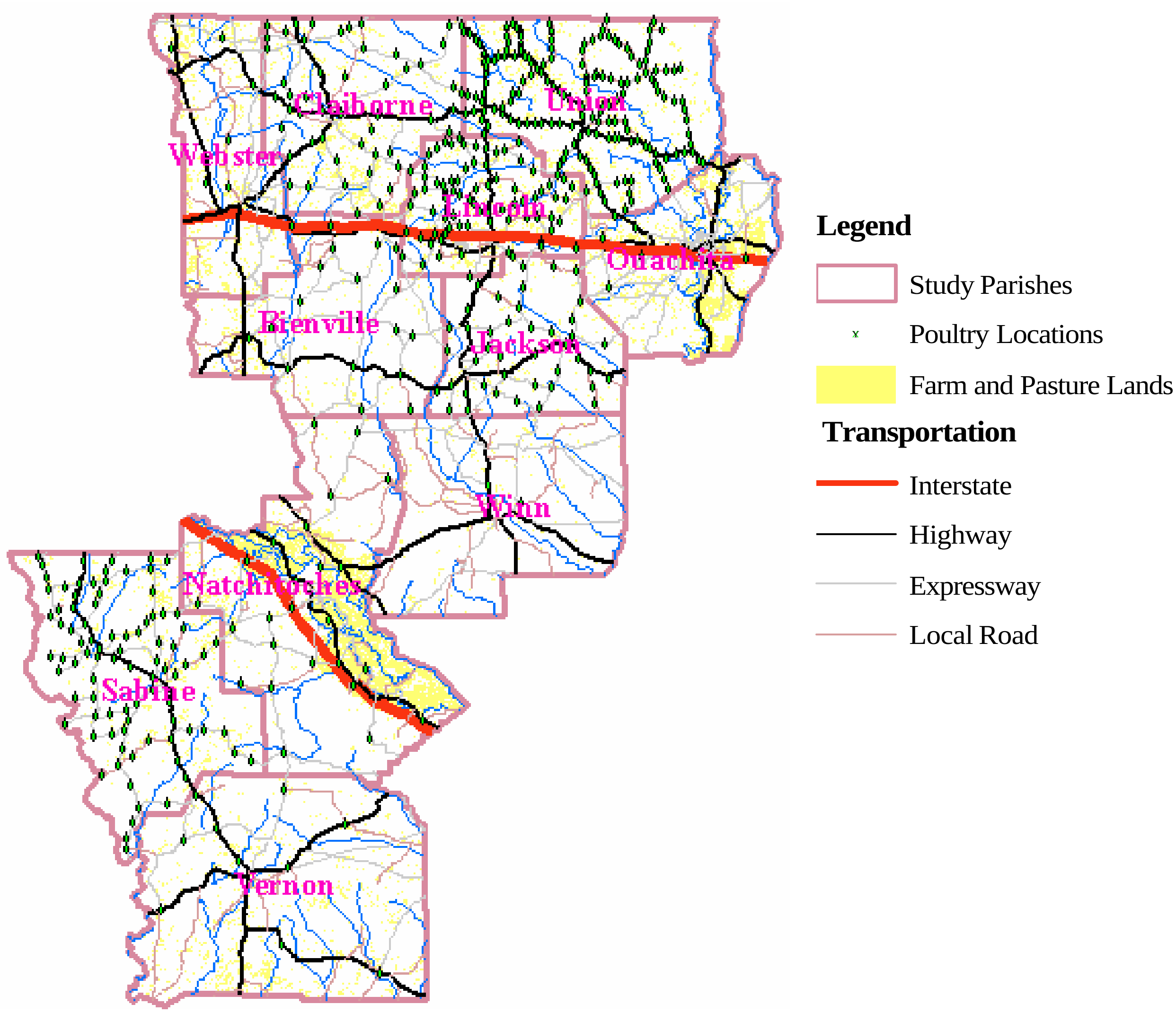
Claiborne
Union
Webster
Lincoln
Ouachita
Bienville
Jackson
Winn
Natchitoches
Sabine
Vernon
Legend
Study Parishes
Poultry Locations
Farm and Pasture Lands
Transportation
Interstate
Highway
Expressway
Local Road

Figure 1

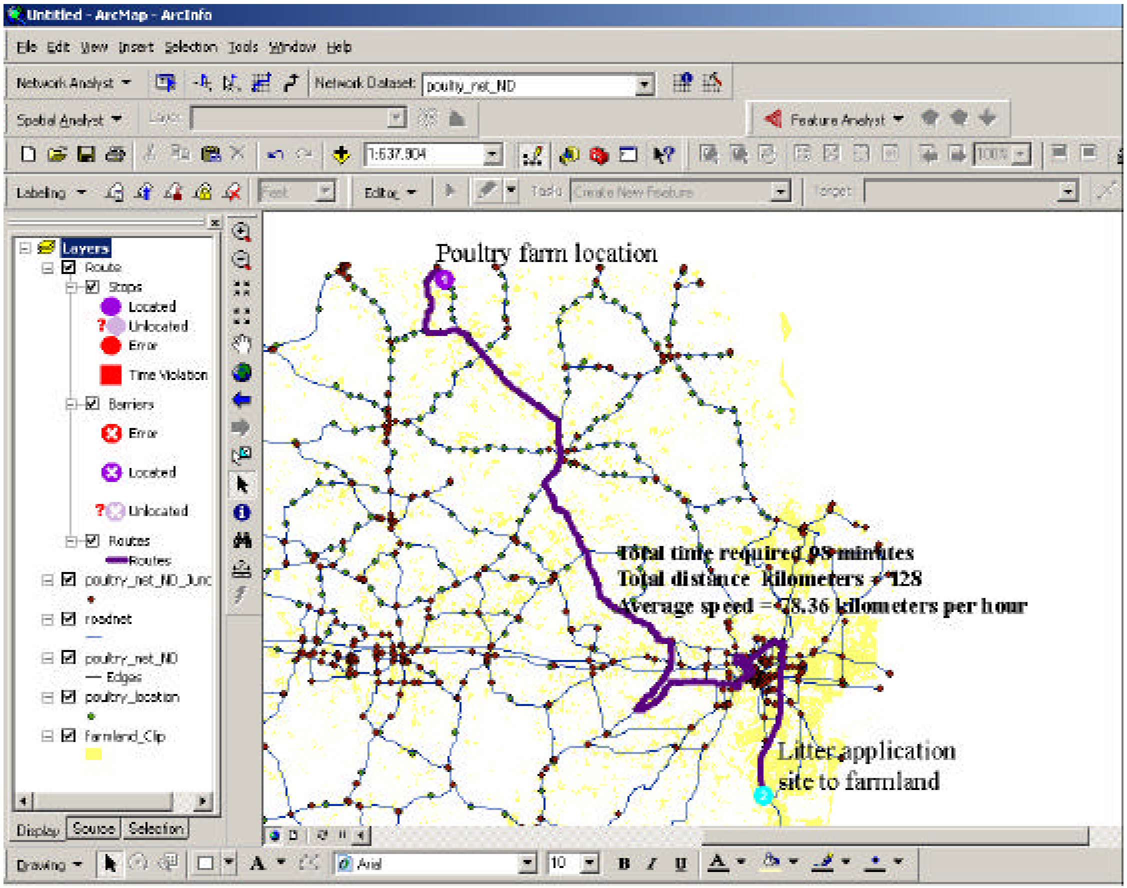

Figure 2. Optimization model showing transportation routes