Report on Financial Feasibility and Market Analysis of Poultry Litter Ash Fertilizer Granules

Prepared for and based on information from Mr. Earl Ray Zimmerman's operation in Ephrata, PA.

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Executive Summary

This document is a technical evaluation of the feasibility of poultry litter ash fertilizer granules. All information contained in this document and corresponding Microsoft Excel workbook are based on several assumptions provided by the grant team and Mr. Earl Ray Zimmerman. There is undoubtedly information not captured here that will affect the financial and market feasibility of the product in question. However, this document and resulting Excel workbook provide a foundation for further evaluation.

From the various financial and market calculations, poultry litter ash fertilizer granule production is a potentially profitable enterprise. From the Enterprise analysis, it was found that the breakeven price per pound of granules is $0.61 which is well below the assumed price received of $0.75 per pound. However, the financial profitability of the enterprise is heavily dependent on the ability of the producer to sell 100% of the granules produced from one broiler house worth of ash. The breakeven price is heavily dependent on the bag size, capacity of the mixing auger, and phosphoric acid to ash ratio. The return on investment under the assumption of 100% of the granules being sold every year reveals a positive return of 14.11% per year on average. Moreover, the payback period on the equipment is approximately 2.5 years. Considering the estimated useful life of the mixing auger is 10 years, this payback period is very reasonable. The mixing auger useful life may be longer than 10 years, but this assumption provides an average valuation on the return on investment. From the market analysis, it was found that the market is highly competitive. At the same time, there are no "local" fertilizer producers that are producing enough product for a home garden market. To increase potential demand for the poultry litter ash fertilizer granule product it may be necessary to incur marketing costs, which would directly impact the financial feasibility of the enterprise. In the remainder of this technical report the assumptions and recommendations for this enterprise are detailed.

Financial Feasibility and Analysis

Before making any business investment, it is paramount to determine the potential financial feasibility of the enterprise. This is done through several analyses that reveal different aspects of the operation. For this project, the feasibility of poultry litter ash granules as a fertilizer was analyzed using Enterprise Budgeting, Cash Flow, Return on Investment, Net Present Value, and Payback Period Analysis. This was followed by several sensitivity analyses to provide a range of potential outcomes. It was found that the granulation of poultry litter ash for use as a fertilizer is potentially profitable, but heavily dependent on how much of the final product can be sold and the price received for the product. In the following sections the assumptions, details, and results of each analysis are discussed. A Microsoft Excel workbook accompanies this document to allow for transparency of all calculations and the ability to see how the financial feasibility of the enterprise changes as assumptions are changed.

General Assumptions

Throughout all the analyses it is assumed that the end market for the poultry litter ash granules are for home lawn/garden use. This is especially important as the assumed price per pound reflects this assumption. This assumption is explained in more detail in the "Market Research" section of the report. For generality of the analysis, it is assumed that this enterprise is based on one broiler chicken house. While multiple broiler houses may exist and can be used to produce the end-product, it is imperative to provide an analysis of a single house for comparability purposes. It is also assumed that the ash-to-acid ratio is 25 pounds of ash to 8 pounds of Phosphoric acid. This is known to be the cheapest blend in which granules form. It is also assumed that there is no weight loss from the mixture of these two elements so that end fertilizer weight total equals the exact combination of weights from ash and acid. It is also assumed that one broiler produces 2.5lbs of litter per year and that one standard ton of litter, when burned, produces 250 pounds of ash.

Cost of equipment is based on quotes provided by various sources. The mixing auger equipment cost was based on a quote obtained by Mr. Earl Ray Zimmerman at a total cost of $7,951.00. The bagging equipment cost used in analysis was based on an average price of $12,000.00 from two potential suppliers. There was a third option that was markedly more expensive and was excluded from the base analysis. The various prices of the bagging equipment is presented below:

Bagging Equipment (3-5lb heat seal)		
Most basic: Semi Auto small scale	Shunxin Engineering	$11,000.00
	Sealing Machine	$600.00
	Total	**$11,600.00**
Slightly more automated	Weigh Right iQ-1E and stand	$10,790.00
	Accessories	$1,795.00
	Total	**$12,585.00**
Allows for bigger and longer bags	Sharp-Max 12	$19,244.00
	Max Deflater	$249.00
	Max 12 Imprinter plus frame	$15,995.00
	Total	**$35,488.00**

Enterprise Budget Analysis

An enterprise budget is a useful tool to test out potential profitability before committing resources and analyze alternatives within that potential enterprise. The four components of the enterprise budget are the title, revenues, costs, and profits. The title lists the useful and pertinent information about the enterprise being analyzed. This should define the distinguishing characteristics of the enterprise. Revenues should list the quantity of each item produced by the enterprise along with an estimate for the price (value) per unit for each revenue generating item. Costs include variable (operating) and fixed (ownership/indirect) costs. Within the variable cost category, it is essential to have the operating cost down to a per unit basis to allow for variations in the input amounts. One must also calculate the annual operating capital – also known as interest on operating capital. This is the sum of all variable costs multiplied by the annual interest rate, which is then multiplied by the proportion of the year the money is used. Fixed (ownership) costs account for the costs of owning equipment and buildings. For these types of costs, it is important to account for various economic costs such as depreciation, interest, repairs, taxes, and insurance. Depreciation is a reduction in value of an asset with the passage of time due to wear and tear. An important assumption that plays a role in the calculation of depreciation are the useful life of the asset(s) and the salvage value if sold at the end of the useful life period. Finally, profits are defined as total revenue minus total costs and where one can determine whether the potential enterprise is profitable. It is important to note that all costs and revenues are assumptions based on calculations and are not necessarily accurate. It is important to obtain as much information as possible in order to be as accurate as possible. To ensure accurate revenues, it is encouraged that the business seek quotes from potential buyers before investing in the enterprise. Any additional assumptions beyond those in the "General Assumptions" subsection are stated within the Microsoft Excel workbook and/or below the Enterprise Budget table of this document.

From the enterprise analysis, it was found that 0-24-24 fertilizer granules composed of poultry litter ash is potentially profitable for home garden markets. Assuming one is able to obtain $0.75 per pound of granules, the enterprise would garner approximately $41,765.63 in revenues. The variable costs would be $31,460.46 and fixed costs would be $2,366.71. This would garner an annual profit of $7,938.46. Based on the total costs, the breakeven price per pound of granules is $0.61, which means this is the minimum price one would have to receive to make exactly $0.00 in profit. This analysis is the foundation of all other financial analyses performed.

The Enterprise Budget is heavily dependent on four components: (1) the ability to sell all 55,687.50 pounds of fertilizer granules in a given year; (2) the quantity of labor necessary to operate the equipment, which is dependent on the size of the mixing auger to know how many batches would need to be run; (3) the number of bags needed, which is contingent on the size of bags used; and (4) the price received ($0.75) per pound of fertilizer granules. The price received of $0.75 is based on wholesale prices for the fertilizer that would then be sold through retail locations. There are few 0-24-24 fertilizer on the market, but numerous competitors in the overall home fertilizer market.

To account for variations in percentage of fertilizer sold, auger capacity, and various price points, sensitivity analysis was conducted. In the first sensitivity analysis, the variation in quantity sold and price received is varied to determine the variation in potential profit. This is done to also account for the potential of two broiler houses worth of product. Under the current price assumption of $0.75 per pound, at least 90% of the granules from one house would have to be sold in order to be profitable. If production expanded to two broiler houses worth of production, 80% of all granules would need to be

sold to remain profitable. This amount varies significantly as price varies. Again, it is highly advisable to seek quotes from potential buyers on quantity and price potential.

Sensitivity analysis on percent quantity sold and breakeven price was also conducted. It was found that more than 80% of all granules would need to be sold to breakeven on one broiler house worth of production. Breakeven price per pound is significantly reduced when expanding to two houses. Finally, auger capacity variation is assumed at 1000 pounds of ash and would cost $1,113.75. If the auger capacity is significantly larger, then the cost of labor is reduced, and profitability is increased. In addition, there would be additional scenarios between price and percent quantity sold that would be possible.

Please see Appendix A: Exploring Robustness of Financial Feasibility for On-Farm Co-product Processing through Stochastic Simulations for an explorative stochastic analysis for this enterprise.

Cash Flow Analysis

Cash flow analysis (also called cash flow budgets) help to plan the dollar pathway by giving a summary of projected inflows and outflows over a given period of time. Cash inflows are those transactions that bring money into the business, which is often revenues and other types of cash investments. Cash outflows represent expenses for the operation including taxes and loan payments. Cash flow analysis is predominantly used to estimate the amount and timing of future needs and one's ability to repay investments. Even though most of the litter burning that creates the ash for the fertilizer product is likely to not happen until the end of the winter months, it was assumed that the creation of fertilizer granules would occur every other month throughout a year's worth of production. This was used to match the average production process of the broiler house – specifically, 6 flocks a year. It is also assumed that all the equipment was paid for in cash at the beginning of year 1. The cost of equipment is assumed the same as that reported in the Enterprise Budget. The cash flow analysis is done every month across a 10-year time horizon to match the assumed useful life of the equipment.
The results of the cash flow analysis in Year 1 show that the enterprise would produce a negative net cash flow for the first year. This is expected as the cash outflows from the initial investment in the equipment and the cost of operating far exceeds the potential revenue. In Year 2, the cash flow reveals a negative net cash ending position again, but the total cash available in the second half of the year begins to show positive revenue streams. By the end of Year 3, the net cash ending position is positive and indicates that the initial investment cost of the equipment has been repaid. The first half of Year 3 still shows negative ending cash positions but is positive in the second half of the year. For the remaining time horizon, the ending cash position for every month for this enterprise is positive. At the end of Year 10, the ending cash position is expected to be approximately $54,700.35.

Return on the Investment

Return on investment is an important aspect of determining the financial feasibility of a new enterprise. Specifically, it allows one to analyze whether an investment/enterprise is profitable in relation to inflation and as compared to other financial investments such as stocks. There are several ways to measure return on an investment. Within this analysis, net present value, annualized return on investment, payback period and internal rate of return are used. Net present value analysis compares the present value of cash as compared to the ultimate return of the cash outcome. In other words, net present value analysis is used to predict whether cash will compound in the future. Return on investment is simply the difference between gains and costs of an investment divided by the initial cost

of the investment. However, annualized return on investment looks at the average return across the entire time horizon. Finally, payback period is how long it will take to recover the initial costs of the investment.

To calculate return on investment, the annual net cash flow from the cash flow analysis is used in combination with the total cost of the investment and an assumed discount rate of 7%. The net present value of the granule fertilizer enterprise after a 10-year time horizon is $14,044.82. The total return on investment is 274.17% which is annualized to 14.11%. Finally, the payback period on the equipment investment is about 2.5 years. Thus, the operation would not see any profits until Year 3, but the long-term investment is profitable. The Net Present Value of approximately $14,044.82 is the value of the investment in today's dollars in the future (10 years from now). Because the value is positive, this means that the investment is worthwhile. Moreover, the investment outperforms the reduction in value from depreciation and inflation. With any investment there is risk involved. These are simply estimates based on several assumptions from research and information provided to the consultant. In other words, there may be better investment opportunities for the money. However, if the goal is to sell a waste by-product then this is a profitable alternative if 100% of the granules can be sold at the specified price of $0.75 per pound.

Market Research Analysis

Market research is vital in determining whether there is a potential for a product to be successful. Specifically, market research helps to identify potential market size, potential price points, retail outlets, and marketing strategies. This is done by analyzing consumer trends, competitor products, and industry trends. For the case of poultry litter ash fertilizer granules, there are two potential markets: small to medium sized farms and home flower/vegetable gardens. The amount of fertilizer granules produced would not be enough for any large farm fertilizing needs.

Small to Medium Sized Farm Market

There is a need for fertilizer in many small and medium sized farms, especially vegetable farms. However, the cost per pound of fertilizer granules is far too expensive as compared to large scale fertilizer alternatives currently on the market. Therefore, it is not suggested to pursue this market alternative. If the cost of granule production could be significantly reduced, then this market option may be viable.

Home Flower/Vegetable Gardens

The home flower and vegetable garden market is a growing market that is worth approximately $3 billion dollars across the entire United States. There is significant potential for poultry litter ash granules to enter this market in a competitive position. The competitive position of the proposed fertilizer granules is dependent on relative proposed price, future growth of the industry, potential retailers, and other related competitors. This section will discuss the price, position, promotion, and place of marketing fertilizer granules.

Price

In the current analysis, the assumed wholesale price of a pound of poultry litter ash fertilizer granules is $0.75. This price is based on the composition of the fertilizer as compared to most other fertilizers in the market. Specifically, a 0-24-24 blend of nitrogen (N), phosphorus (P), and Potassium (K) is rare in the market. All competing products have some percentage of nitrogen. The product with the lowest percentage of nitrogen was organic bone meal with 3%. The average retail price per pound of competing products is $2.43 with the cheapest competitor option at $0.30 and the most expensive competitor option at $3.70 per pound. By having a lower wholesale, and thereby lower retail price per pound, the proposed fertilizer product will have greater success in penetrating the market. Again, it is important to note that the $0.75 is assumed to be a wholesale price as it would be necessary to use a retailer to sell the product to home garden consumers and thus, a markup on the wholesale price imposed by the retailer. This price is still assumed and is dependent on actual negotiation of a contract based on a retailer.

Position

In marketing, one of the key components to have in mind before ever bringing a product to market is positioning. Positioning is about the space that a product holds in the mind of consumers. Many marketers surmise position as a combination of price and perceived quality. While this is an important component of marketing position, one must also consider how a new product distinguishes itself from the products of competitors. A firm communicates this position to consumers through marketing efforts.

In the case of 0-24-24 poultry litter ash fertilizer granules, the position is quite unique. With the proper marketing/information campaign this could fill a hole in the current offerings of the home garden fertilizer market. As previously mentioned, there are very few 0-24-24 mixes of fertilizer on the market. This may be due to the idea that nitrogen is the most sought-after element in fertilizer as it is usually the limiting factor in plant growth. However, the current market area (Pennsylvania) may not need the nitrogen additive as it is abundant in the soil. Further, additional soil applications of nitrogen could increase non-point pollution of local watersheds. Information about these issues should be used as a part of any package advertising. Another set of marketing positions this fertilizer can take is the fact that phosphorus promotes root growth in plants, and that potassium enhances individual bloom/fruit quality. Thus, this fertilizer product could fit a very specific position of being used for small (home) flower and vegetable gardens. Of the current 0-24-24 fertilizer products on the market, common marketing campaigns use terms such as "bloom booster" and discuss the purpose of this fertilizer in increasing size and mass of flowers and fragrance production in herbs (https://humboldtcountysown.com/product/crystal-burst-0-15-15/).

Finally, an additional position would be to change the product formulation to a 15-24-24 blend. This appears to be the most common fertilizer blend on the market today. While the market for this specific product would likely be expanded with the addition of nitrogen, this would increase the cost of production and number of direct competitors. While it is reasonable to assume that the cost of adding nitrogen to the fertilizer product will not increase price over competitor's prices, it is imperative that the retail price remain low in order to compete with well established brands. Thus, the return on investment, payback period, and net present value of the enterprise would put a producer in a worse position.

Promotion

Promotion is the part of marketing where strategies to reach consumers are discussed. Specifically, what modes of advertising would be optimal to reach the largest number of consumers and penetrate the existing market. It is important to note that any promotional strategies will increase the operating/variable costs of the enterprise and are <u>not</u> included in the financial analysis. The additional costs associated with various marketing strategies will be discussed within this section to aid in decision making.

As previously mentioned, there is an opportunity to discuss the market position for this product versus a traditional bag of fertilizer. Consumers are trending toward more environmentally conscious products and discussing the potential of reducing excess nitrogen in local watersheds should be a focus of any marketing campaign. Another promotional piece to include on the bag is the farm story. Consumers, especially millennials, are more concerned about supporting local enterprises. These key trends are important to expanding your market presence. Farm stories directly on products have been a growing part of local agricultural marketing and has shown to increase demand. There are few, if any, local fertilizer producers and this could be a promotional strategy that will be the most effective. This strategy would require custom bags and likely increase bag cost. However, the marginal cost of bags is relatively low, <u>but </u>total costs of bags for a year is heavily dependent on bag size. Currently, the assumed bag size is 50lbs, which is likely too large for many home gardens. At the same time, fertilizer is storable, and some consumers may prefer to buy in bulk. More consumer research is necessary to determine the optimal bag size. Current competitors sell flower garden fertilizer in 4 to 8-pound bags, while lawn and garden fertilizer is typically sold in 10-25 pound bags. There are a few options sold at the 50-pound bag size. See the table below for a comparison of popular home garden fertilizers.

Retailer	Fertilizer Product	Price Per Pound
Ag Way	15-15-15 Fertilizer from AgWay 50lb Sack is $15	$ 0.30
Amazon	24-8-16 Miracle Grow 10lb Water Soluble is $22	$ 2.20
Amazon	20-20-20 Grow More 2010 25lb Sack is $52.25	$ 2.09
Amazon	15-5-15 Schultz spf48410 Rose & Flower 3.5lb sack is $13	$ 3.70
Amazon	15-9-12 Osmocote Outdoor & Indoor 8lb is $25.12	$ 3.14
Amazon	14-14-14 Osmocote Flower & Vegetable 8lb is $27	$ 3.38
Amazon	3-15-0 Organic Bone Meal 5lb is $18.50	$ 3.70
Ag Way	30-0-3 AgWay Lawn Fertilizer 16lb is $15	$ 0.94

In addition to the environmental and farm story strategies, it is important to note that millennials are doing more home vegetable gardening than previous generations. Again, this is due to a growing

consumer base that is interested in local, sustainable agriculture. By producing a local fertilizer product, the potential is there to attract the millennial consumer base to this product. By combining the marketing messages about local, environmental sustainability, and farm story one could attract a sufficient portion of the home garden fertilizer market to this product.

Finally, as can be seen in the fertilizer competitor table above, most of the competitor products are much more expensive on a per pound basis. While part of this is due to being well known brands, there is also a significant amount of marketing costs reflected in that price. Moreover, these are retail prices which means that the price received by the producers/firms is much lower. However, there is potential to sell the poultry litter ash fertilizer for similar prices, but in larger quantities. This would appeal to bulk buyers and those that are more price conscious. At the same time, knowing how much a potential retailer will markup the price is important for determining this potential promotional strategy.

Place

In marketing, place refers to the physical place or location where the product will be sold. This is important as it does affect market penetration and overall firm profitability. Looking at the local, county level market (Lebanon County, PA). There are approximately 142,000 people living in the county. Currently there is a Home Depot and a Lowe's Home Improvement Store within the county both of which have more than $26 million in annual revenue with Lowe's Home Improvement having a higher annual revenue in 2019 at almost $31 million. In addition, there are three other retail locations within the county that sell fertilizer for the home garden market: Growmark FS, Kirby Agri Inc., Leiby's Inc., as well as Local AgWays, Amazon, etc. The store with the most annual revenue in 2019 was Growmark FS at over $11 million and Leiby's Inc. was the smallest retail location with almost $400,000 in annual revenue. Thus, the largest consumer base would be at the Lowe's Home Improvement store, but it is unknown whether they (or Home Depot) would be willing to sell a local fertilizer product. It is not suggested to target Growmark FS as they have a larger consumer base that is primarily agricultural producers. Kirby Agri Inc. may be the better alternative as they are a wholesale distributor. Leiby's Inc. may also be a potential location to sell as they are focused on landscaping but may require a nitrogen component to be competitive. Statewide (Pennsylvania) there are 79 non-chain retail locations that are potential retail locations. Many of these locations are associated with Agway or are local nurseries, all of which already attracts the desired consumer base. These are the types of locations that would attract those most concerned about the local aspect of products.

If the desire is to broaden the potential consumer base beyond the state of Pennsylvania, then Amazon may be a potential option. Amazon would help to significantly increase the market size of the product. However, there would be additional costs from shipping and Amazon will also take a percentage of revenue. This would mean that the product price would have to increase, or the marginal profit would be reduced. Again, a reduction in profit will significantly affect financial feasibility of the enterprise. In reality, a combination of all potential retail locations may be the optimal strategy but would require additional promotional, shipping/transportation, and labor costs to increase feasibility of the enterprise.

Size

The final component of understanding the marketing potential of any product is analyzing the size of the market. Within the United States, the home fertilizer market is worth approximately $3 billion annually (The Freedonia Group, 2018). Research suggests that 77% of U.S. households have a garden (Garden Research, 2018) and that there are approximately 105,480,101 households throughout the country (U.S. Census Bureau, 2020). Therefore, the average annual fertilizer expenditure for those households with a

garden is approximately $36.94. Based on the aforementioned numbers, there are approximately 3,678,292 households in Pennsylvania with a garden which means the home garden fertilizer market for the state is worth about $135,864,574. If it is assumed that the average annual fertilizer purchase is 15 pounds, then consumers are paying an average of $2.46 per pound of fertilizer. Note, this is retail expenditure and not wholesale. Also note, that this does not separate out the type of fertilizer or the purpose of the fertilizer. If it is assumed consumers purchase 50 pounds of fertilizer every year, then the average cost per pound is $0.74, which is close to the price assumed in the financial analysis. Overall, there is a sizable market in the state, but determining the potential market penetration for a local, poultry litter ash fertilizer granule is difficult to estimate given that it does not currently exist in the market.

Marketing Recommendations

With the vast number of unknowns about potential retail marketability, it is recommended to contact several potential retailers to determine their willingness to sell the product. Moreover, it is imperative to determine the quantity and price they would desire. This will all play a role in the financial feasibility of the enterprise. If the desire is to promote and sell the product directly from the farm, appropriate marketing costs in the range of $5,000-$20,000 per year would need to be accounted for in the financial feasibility analysis.

Other Market Alternatives

Other options besides producing the fertilizer granules would be to transport the ash to a landfill, attempt to sell the ash as a fertilizer product, or outsource the granule production. A brief discussion of each alternative will be discussed and whether any of these may be a feasible option. Transportation to a local landfill will incur transportation costs and waste disposal fees. The average price per mile of transportation is approximately $0.10 and the average waste disposal fee in Pennsylvania is $90 per ton. The total waste disposal fee for the amount of ash produced from one broiler house would be approximately $1,890 per year. Even if the ash must be transported to a landfill 100 miles away, the total cost of disposing of the ash would be around $2,000 a year. If the savings from producing heat from the litter are sufficient, then this additional cost to the operation may be easily absorbed.

Selling the free-ash product as fertilizer may be a potential option. Small scale vegetable and soybean/edamame operations may be viable clients. Many of these operations need between 50 and 200 pounds of potash per acre. The average price of free-ash is approximately $0.16 per pound which would result in gross revenue between $8 and $32 per acre covered, or $6,750 for the total amount of ash produced. However, this may not be the preferred form of a fertilizer product for many small and medium sized farms. This is a market opportunity that would have to be cultivated directly with local farmers.

Outsourcing the granule production is likely infeasible given that the closest granule production center is in Newton, North Carolina (http://carolinapelleting.com/?page_id=10). This would incur significant costs in transportation and would likely equate to producing the granules oneself or be more expensive. Therefore, this market opportunity is not explored further.

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Financial Feasibility Tables

Enterprise Budget for Poultry litter ash granules for a broiler house (Year 1 - 6 flocks of 22,500 birds per year)

Outputs (Revenue)		Units	Quantity	Price	$/House/year
	Fertilizer (0-24-24)	lbs	55,687.50	$0.75	$41,765.63
Variable Costs					
	Ash (from poultry litter)	lbs	42,187.50	$0.00	$0.00
	Phos Acid (8lbs to 25lbs ash)	lbs	13,500.00	$1.14	$15,390.00
	Labor	hours	1,113.75	$13.34	$14,857.43
	Bags	count	1,113.75	$0.20	$222.75
	Other Costs	dollars		$ -	$0.00
	Marketing Costs	dollars		$ -	$0.00
	Annual Operating Capital	dollars	$15,235.09	6.50%	$990.28
Total Operating Costs					$31,460.46
Returns Above total Operating Costs					$10,305.17
Fixed Costs				Rate	
Mixing Auger					
Average Value			$7,951.00		
Proportion Charged			100.00%		
	Interest	$		6.00%	$477.06
	Taxes	$		1.00%	$79.51
	Insurance	$		0.85%	$67.58
	Depreciation	$			$319.04
Bagging Equipment					
Average Value			$12,000.00		
Proportion Charged			100.00%		
	Interest	$		6.00%	$720.00
	Taxes	$		1.00%	$120.00
	Insurance	$		0.85%	$102.00
	Depreciation	$			$481.52
Storage/Buildings			$0.00		
	Interest	$		3.00%	$0.00
	Taxes	$		0.40%	$0.00
Total Fixed Costs					$2,366.71
Total Costs (Operating + Fixed)					$33,827.17
Returns Above All Specified Costs					$7,938.46
				Breakeven	$0.61

Notes: Quantity is dependent on whether there is any weight loss from mixing ash and acid; Price is based on annual home gardener expenditure; labor is assuming 10 minutes of 2 persons time and 1000 pounds per run in mixing auger; wage rate is based on PA state level adverse wage rate; Bag Quantity is based on 50lb bags; Annual operating capital covers repairs, maintenance, electricity cost, etc.

Profit Sensitivity analysis for price per pound of fertilizer and quantity of fertilizer sold

Percentage of Quantity Sold	Price per Pound												
	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1
0.5	$ (19,905.29)	$ (18,513.11)	$ (17,120.92)	$ (15,728.73)	$ (14,336.54)	$ (12,944.36)	$ (11,552.17)	$ (10,159.98)	$ (8,767.79)	$ (7,375.61)	$ (5,983.42)	$ (4,591.23)	$ (3,199.04)
0.6	$ (17,120.92)	$ (15,450.29)	$ (13,779.67)	$ (12,109.04)	$ (10,438.42)	$ (8,767.79)	$ (7,097.17)	$ (5,426.54)	$ (3,755.92)	$ (2,085.29)	$ (414.67)	$ 1,255.96	$ 2,926.58
0.7	$ (14,336.54)	$ (12,387.48)	$ (10,438.42)	$ (8,489.36)	$ (6,540.29)	$ (4,591.23)	$ (2,642.17)	$ (693.11)	$ 1,255.96	$ 3,205.02	$ 5,154.08	$ 7,103.14	$ 9,052.21
0.8	$ (11,552.17)	$ (9,324.67)	$ (7,097.17)	$ (4,869.67)	$ (2,642.17)	$ (414.67)	$ 1,812.83	$ 4,040.33	$ 6,267.83	$ 8,495.33	$ 10,722.83	$ 12,950.33	$ 15,177.83
0.9	$ (8,767.79)	$ (6,261.86)	$ (3,755.92)	$ (1,249.98)	$ 1,255.96	$ 3,761.89	$ 6,267.83	$ 8,773.77	$ 11,279.71	$ 13,785.64	$ 16,291.58	$ 18,797.52	$ 21,303.46
1	$ (5,983.42)	$ (3,199.04)	$ (414.67)	$ 2,369.71	$ 5,154.08	$ 7,938.46	$ 10,722.83	$ 13,507.21	$ 16,291.58	$ 19,075.96	$ 21,860.33	$ 24,644.71	$ 27,429.08
2 houses of Ash													
1.1	$ (34,659.50)	$ (31,596.69)	$ (28,533.87)	$ (25,471.06)	$ (22,408.25)	$ (19,345.44)	$ (16,282.62)	$ (13,219.81)	$ (10,157.00)	$ (7,094.19)	$ (4,031.37)	$ (968.56)	$ 2,094.25
1.2	$ (31,875.12)	$ (28,533.87)	$ (25,192.62)	$ (21,851.37)	$ (18,510.12)	$ (15,168.87)	$ (11,827.62)	$ (8,486.37)	$ (5,145.12)	$ (1,803.87)	$ 1,537.38	$ 4,878.63	$ 8,219.88
1.3	$ (29,090.75)	$ (25,471.06)	$ (21,851.37)	$ (18,231.69)	$ (14,612.00)	$ (10,992.31)	$ (7,372.62)	$ (3,752.94)	$ (133.25)	$ 3,486.44	$ 7,106.13	$ 10,725.81	$ 14,345.50
1.4	$ (26,306.37)	$ (22,408.25)	$ (18,510.12)	$ (14,612.00)	$ (10,713.87)	$ (6,815.75)	$ (2,917.62)	$ 980.50	$ 4,878.63	$ 8,776.75	$ 12,674.88	$ 16,573.00	$ 20,471.13
1.5	$ (23,522.00)	$ (19,345.44)	$ (15,168.87)	$ (10,992.31)	$ (6,815.75)	$ (2,639.19)	$ 1,537.38	$ 5,713.94	$ 9,890.50	$ 14,067.06	$ 18,243.63	$ 22,420.19	$ 26,596.75
1.6	$ (20,737.62)	$ (16,282.62)	$ (11,827.62)	$ (7,372.62)	$ (2,917.62)	$ 1,537.38	$ 5,992.38	$ 10,447.38	$ 14,902.38	$ 19,357.38	$ 23,812.38	$ 28,267.38	$ 32,722.38
1.7	$ (17,953.25)	$ (13,219.81)	$ (8,486.37)	$ (3,752.94)	$ 980.50	$ 5,713.94	$ 10,447.38	$ 15,180.81	$ 19,914.25	$ 24,647.69	$ 29,381.13	$ 34,114.56	$ 38,848.00
1.8	$ (15,168.87)	$ (10,157.00)	$ (5,145.12)	$ (133.25)	$ 4,878.63	$ 9,890.50	$ 14,902.38	$ 19,914.25	$ 24,926.13	$ 29,938.00	$ 34,949.88	$ 39,961.75	$ 44,973.63
1.9	$ (12,384.50)	$ (7,094.19)	$ (1,803.87)	$ 3,486.44	$ 8,776.75	$ 14,067.06	$ 19,357.38	$ 24,647.69	$ 29,938.00	$ 35,228.31	$ 40,518.63	$ 45,808.94	$ 51,099.25
2	$ (9,600.12)	$ (4,031.37)	$ 1,537.38	$ 7,106.13	$ 12,674.88	$ 18,243.63	$ 23,812.38	$ 29,381.13	$ 34,949.88	$ 40,518.63	$ 46,087.38	$ 51,656.13	$ 57,224.88

Profit Sensitivity analysis for price per pound of fertilizer and quantity of fertilizer sold

Percentage of Quantity Sold	Price per Pound							
	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5
0.5	$(1,806.86)	$ (414.67)	$ 977.52	$ 2,369.71	$ 3,761.89	$ 5,154.08	$ 6,546.27	$ 7,938.46
0.6	$ 4,597.21	$ 6,267.83	$ 7,938.46	$ 9,609.08	$ 11,279.71	$ 12,950.33	$ 14,620.96	$ 16,291.58
0.7	$ 11,001.27	$ 12,950.33	$ 14,899.39	$ 16,848.46	$ 18,797.52	$ 20,746.58	$ 22,695.64	$ 24,644.71
0.8	$ 17,405.33	$ 19,632.83	$ 21,860.33	$ 24,087.83	$ 26,315.33	$ 28,542.83	$ 30,770.33	$ 32,997.83
0.9	$ 23,809.39	$ 26,315.33	$ 28,821.27	$ 31,327.21	$ 33,833.14	$ 36,339.08	$ 38,845.02	$ 41,350.96
1	$ 30,213.46	$ 32,997.83	$ 35,782.21	$ 38,566.58	$ 41,350.96	$ 44,135.33	$ 46,919.71	$ 49,704.08
2 houses of Ash								
1.1	$ 5,157.06	$ 8,219.88	$ 11,282.69	$ 14,345.50	$ 17,408.31	$ 20,471.13	$ 23,533.94	$ 26,596.75
1.2	$ 11,561.13	$ 14,902.38	$ 18,243.63	$ 21,584.88	$ 24,926.13	$ 28,267.38	$ 31,608.63	$ 34,949.88
1.3	$ 17,965.19	$ 21,584.88	$ 25,204.56	$ 28,824.25	$ 32,443.94	$ 36,063.63	$ 39,683.31	$ 43,303.00
1.4	$ 24,369.25	$ 28,267.38	$ 32,165.50	$ 36,063.63	$ 39,961.75	$ 43,859.88	$ 47,758.00	$ 51,656.13
1.5	$ 30,773.31	$ 34,949.88	$ 39,126.44	$ 43,303.00	$ 47,479.56	$ 51,656.13	$ 55,832.69	$ 60,009.25
1.6	$ 37,177.38	$ 41,632.38	$ 46,087.38	$ 50,542.38	$ 54,997.38	$ 59,452.38	$ 63,907.38	$ 68,362.38
1.7	$ 43,581.44	$ 48,314.88	$ 53,048.31	$ 57,781.75	$ 62,515.19	$ 67,248.63	$ 71,982.06	$ 76,715.50
1.8	$ 49,985.50	$ 54,997.38	$ 60,009.25	$ 65,021.13	$ 70,033.00	$ 75,044.88	$ 80,056.75	$ 85,068.63
1.9	$ 56,389.56	$ 61,679.88	$ 66,970.19	$ 72,260.50	$ 77,550.81	$ 82,841.13	$ 88,131.44	$ 93,421.75
2	$ 62,793.63	$ 68,362.38	$ 73,931.13	$ 79,499.88	$ 85,068.63	$ 90,637.38	$ 96,206.13	$ 101,774.88

Breakeven price per pound sensitivity analysis for quantity of fertilizer sold

Percent Quantity Sold	Breakeven Price
0.5	$ 1.21
0.6	$ 1.01
0.7	$ 0.87
0.8	$ 0.76
0.9	$ 0.67
1	$ 0.61
2 houses of Ash	
1.1	$ 0.55
1.2	$ 0.51
1.3	$ 0.47
1.4	$ 0.43
1.5	$ 0.40
1.6	$ 0.38
1.7	$ 0.36
1.8	$ 0.34
1.9	$ 0.32
2	$ 0.30

Total yearly labor cost sensitivity analysis for auger capacity

Auger Capacity (lbs)	Labor Cost
250	$ 4,455.00
500	$ 2,227.50
750	$ 1,485.00
1000	$ 1,113.75
1250	$ 891.00
1500	$ 742.50
1750	$ 636.43
2000	$ 556.88
2 houses of Ash	
250	$ 8,910.00
500	$ 4,455.00
750	$ 2,970.00
1000	$ 2,227.50
1250	$ 1,782.00
1500	$ 1,485.00
1750	$ 1,272.86
2000	$ 1,113.75

Return on Investment (ROI), Net Present Value (NPV), and Payback Period Analysis

Net Present Value, Return on Investment, and Payback Period Calculations			
		Total Cost of Investment	$19,951.00
Year 1 End Cash Flow	-$12,012.54	Year 1 Net Cash Flow	-$12,012.54
Year 2 End Cash Flow	-$4,204.92	Year 2 Net Cash Flow	$7,807.62
Year 3 End Cash Flow	$3,158.24	Year 3 Net Cash Flow	$7,363.16
Year 4 End Cash Flow	$10,521.40	Year 4 Net Cash Flow	$7,363.16
Year 5 End Cash Flow	$17,884.55	Year 5 Net Cash Flow	$7,363.16
Year 6 End Cash Flow	$25,247.71	Year 6 Net Cash Flow	$7,363.16
Year 7 End Cash Flow	$32,610.87	Year 7 Net Cash Flow	$7,363.16
Year 8 End Cash Flow	$39,974.03	Year 8 Net Cash Flow	$7,363.16
Year 9 End Cash Flow	$47,337.19	Year 9 Net Cash Flow	$7,363.16
Year 10 End Cash Flow	$54,700.35	Year 10 Net Cash Flow	$7,363.16
Net Present Value			**$14,044.82**
Return on Investment			**274.17%**
Annualized ROI			**14.11%**
Payback Period (Years)			**2.56**

Notes: This assumes all fertilizer granules are sold every year; assuming 10 useful life of the equipment; discount rate of 7% is national 2020 rate; assumes only one house worth of ash; see attached excel workbook for full 10-year cash flow analysis.

Example of Cash Flow Analysis for first year of enterprise for one house worth of ash production

Year 1												
Cash inflows	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Starting cash position	$0.00	-$19,951.00	-$18,233.47	-$18,233.47	-$16,515.94	-$16,515.94	-$14,798.42	-$14,798.42	-$13,080.89	-$13,080.89	-$11,363.36	-$11,363.36
Net cash income	$0.00	$6,960.94	$0.00	$6,960.94	$0.00	$6,960.94	$0.00	$6,960.94	$0.00	$6,960.94	$0.00	$6,960.94
Total cash available	$0.00	-$12,990.06	-$18,233.47	-$11,272.53	-$16,515.94	-$9,555.01	-$14,798.42	-$7,837.48	-$13,080.89	-$6,119.95	-$11,363.36	-$4,402.42
Cash outflows	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Capital purchase (cash req'd for down payments)	$19,951.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Long-term loan principal payments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Intermediate-term loan principal payments	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cost of Operating Equipment	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41
Yearly Fixed Costs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,366.71
Dividends (or Owner's Draw)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
State income tax (PA)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Federal income tax	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total cash outflows	$19,951.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$5,243.41	$0.00	$7,610.12
Ending cash position	-$19,951.00	-$18,233.47	-$18,233.47	-$16,515.94	-$16,515.94	-$14,798.42	-$14,798.42	-$13,080.89	-$13,080.89	-$11,363.36	-$11,363.36	-$12,012.54

Notes: Year 1 of cash flow analysis specific to the poultry litter ash granule enterprise; see excel workbook for full 10-year cash flow analysis

Appendix A:

Exploring Robustness of Financial Feasibility for On-Farm Co-product Processing through Stochastic Simulations

Clinton Neill, John Ignosh, Mark Reiter

Context:

The earlier sections of this report have outlined the feasibility of on-farm co-product processing through development of an enterprise budget and via single-point estimates and sensitivity analysis. As alluded to in earlier sections, there are several unknowns associated with the new proposed enterprise, process, and market. These unknowns represent a form of risk and uncertainty to the operation, and with it, to the decision maker, who in this case is the farmer. Uncertainty is often described as lack of awareness of the range of possible outcomes due to limited information. Risk is typically described as the range of possible outcomes and their relative likelihood. Therefore, uncertainty can typically be improved with better information while the understanding of potential outcomes and their relative likelihoods needs to be fully understood to characterize the innate risk with a particular activity.

Stochastic simulation is a further step toward assessing the overall robustness for profitability of the proposed enterprise. In this case, the range of unknowns can be used to describe the distributions of the relative probabilities of certain inputs. These initial ranges can reflect the relative degree of unknowns in financial model assumptions. Much like the sensitivity analysis, the relative impacts across the input variability can help focus where future refinements are needed due to their disproportionate impact on overall system profitability. The simulation process enables running thousands of iterations using randomly selected values from the distribution of each input variable to estimate the robustness of project viability, whereby the impacts, and interplay, of joint probabilities across a wider range of model inputs can be explored through the stochastic model.

Methodology:

Excel-enabled software from the Palisade Company, LLC was used to adapt the enterprise budget model to enable stochastic simulations. The inputs used to develop the enterprise budget were used to define the input distribution for selected parameters. In this exploratory application the case for use of a variety of distributions for each input can often be made. For example, a common approach is to apply a uniform distribution between some minimum and maximum values, until better, more refined, information becomes available to inform use of a particular distribution for a certain variable. However, in our current application, the distribution for each input was assumed to be triangular. The triangular distribution is often used in initial estimations, and consists of three values: minimum, maximum, and most likely. The results of the analysis can help prioritize where additional information is needed, and distributions updated accordingly. Table 1 provides a summary of the inputs included in the stochastic model and describes the parameters used to define their triangular distributions. A series of 10,000 iterations were run using a Latin Hypercube sampling process to draw random samples from the selected distributions. For each distribution, one sample value is selected for each of the iterations. In comparison to Monte Carlo simulation, Latin Hypercube sampling forces the drawn samples to correspond more closely with the input distribution, resulting in more efficient computational convergence. (*Simulation Process Guides* - Palisade, 2021)

Table 1: Assumed Triangular Distributions for Selected Model Inputs for Stochastic Model

Name	Graph	Minimum	Maximum	Mean	Std. Deviation
Bag Cost		$ 0.10	$ 0.50	$ 0.30	$ 0.08
Bag Quantity		1,114	6,961	4,037	1,194
Bagging Equipment Cost		$ 11,600.00	$ 14,000.00	$ 12,800.00	$ 489.90
Fertilizer Quantity		55,688	62,438	59,063	1,378
Insurance		0.8%	1.0%	0.9%	0.1%
Interest		4.0%	8.0%	6.0%	0.8%
Labor Cost		$ 10.00	$ 15.00	$ 12.50	$ 1.02
Mixing Auger Cost		$ 6,500.00	$ 15,000.00	$ 10,750.00	$ 1,735.06
Acid Cost		$ 9.10	$ 25.27	$ 17.19	$ 3.30
Final Product Price per Pound		$ 0.50	$ 1.00	$ 0.75	$ 0.10
Taxes		0.5%	1.5%	1.0%	0.2%

Results & Discussion:

Figure 1 describes the probability density function (PDF) for the stochastic model incorporating the distributions of the selected model inputs described in Table 1. The PDF suggests that there is approximately 12% probability of generating a positive net present value (NPV), with NPV values greater than $0 and a maximum NPV of approximately $164K. For reference, the single point estimate suggests an NPV of approximately $14K, the stochastic model suggests a probability of meeting, or exceeding, this value of 9%. By contrast, there is a 91% probability of generating an NPV less than this value. Figure 2 is a tornado graph which describes the change in output statistic by input. This graph suggests that the price per pound of finished product and price per pound of acid for processing each heavily impact the probability for financial success.

If, for example, through additional market research and process optimization, we were able to increase the projected minimum price per pound of finished product by 20% (e.g., from $0.50 to $0.60) and decrease the price per pound of acid for processing by 20% (e.g., from $3.16 to $2.53) we can use the stochastic model to assess the impact of these improvements to overall project viability. Figures 3 and 4 present the PDF and tornado graph for these revised assumptions. This modified scenario suggests an increase in probability from 12% to 33% chance for enterprise profitability. This approach should assist

in guiding future research to help increase potential profitability along with environmental sustainability.

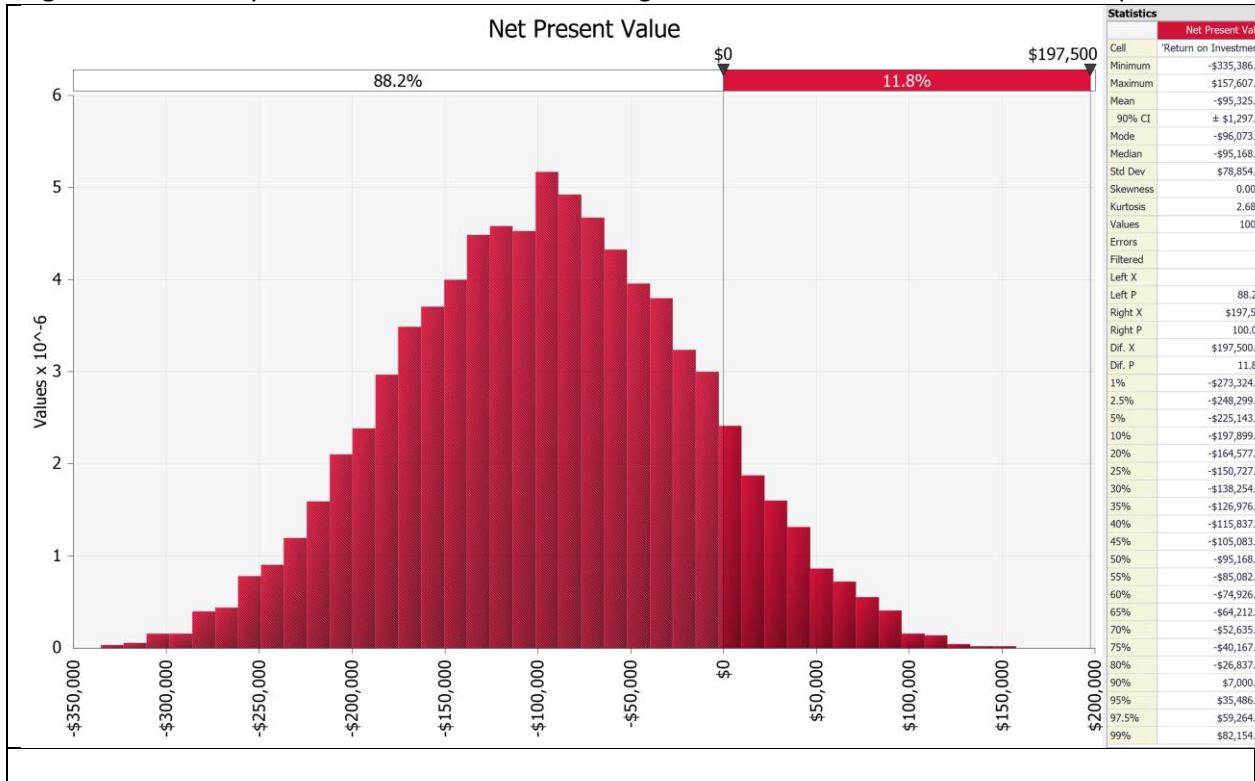**Figure 1:** Probability Distribution Function Describing NPV with Selected Stochastic Model Inputs

Figure 2: Tornado Graph Describing Change in Output Statistic by Selected Stochastic Model Input
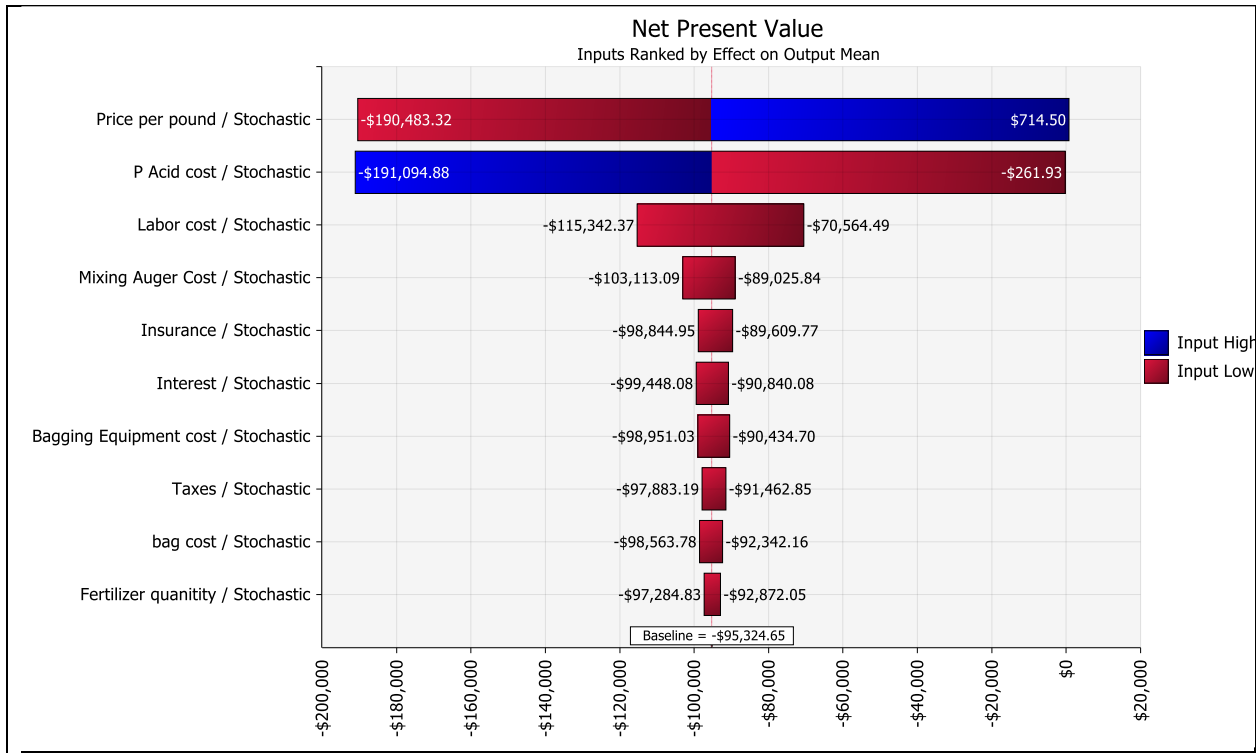
Figure 3: Probability Distribution Function Describing NPV with Selected & Revised Stochastic Model Inputs
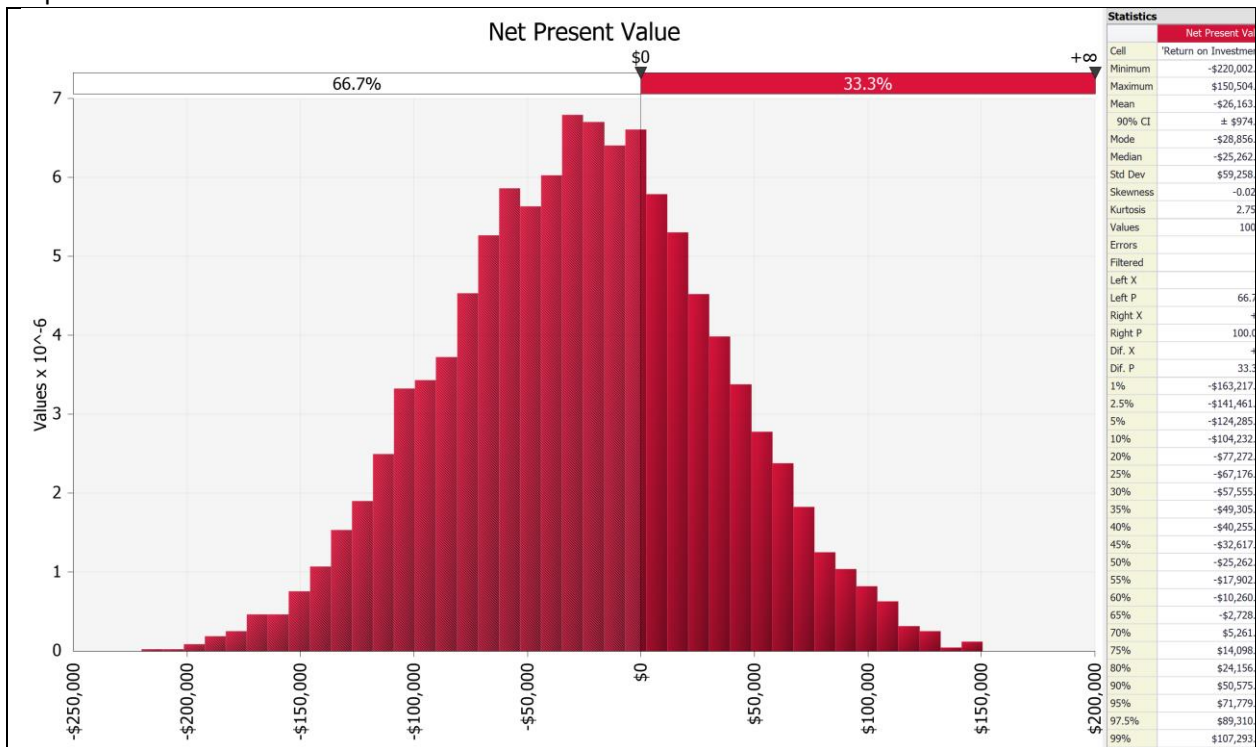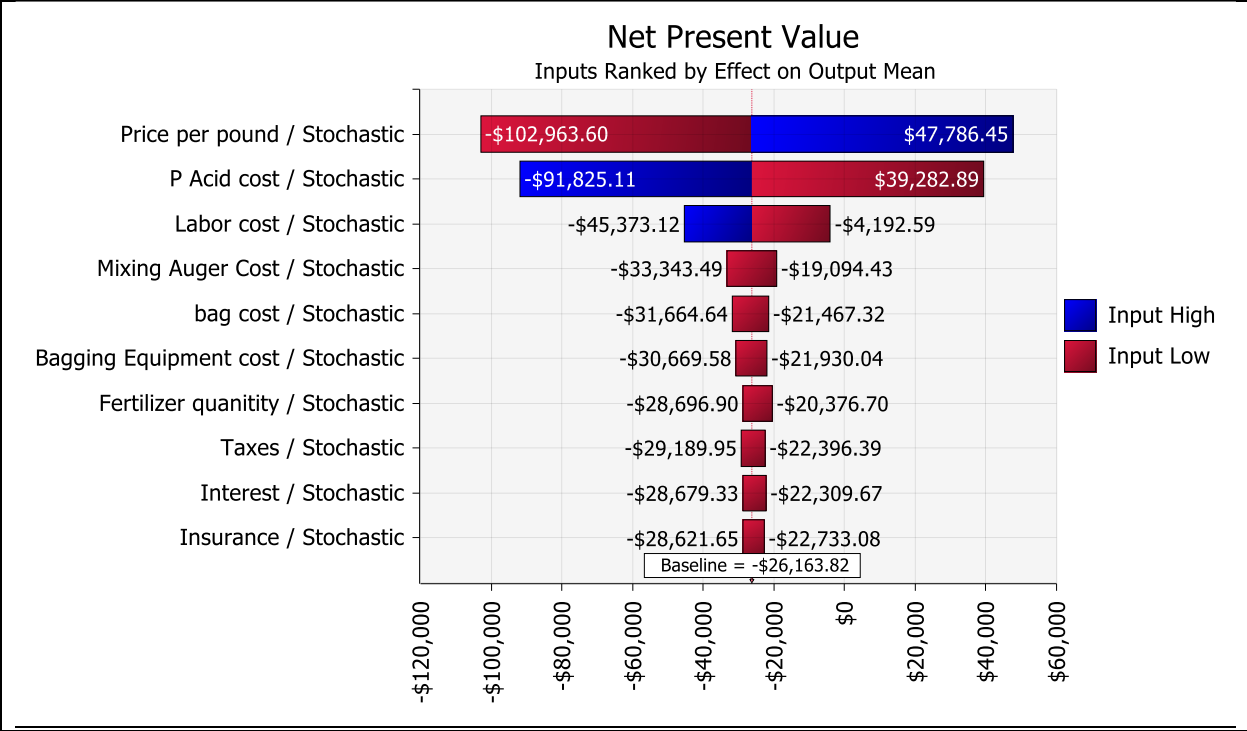

Figure 4: Tornado Graph Describing Change in Output Statistic by Selected & Revised Stochastic Model Inputs

Net Present Value
Inputs Ranked by Effect on Output Mean

Input	Input High / Input Low values
Price per pound / Stochastic	-$102,963.60 → $47,786.45
P Acid cost / Stochastic	-$91,825.11 → $39,282.89
Labor cost / Stochastic	-$45,373.12 → -$4,192.59
Mixing Auger Cost / Stochastic	-$33,343.49 → -$19,094.43
bag cost / Stochastic	-$31,664.64 → -$21,467.32
Bagging Equipment cost / Stochastic	-$30,669.58 → -$21,930.04
Fertilizer quanitity / Stochastic	-$28,696.90 → -$20,376.70
Taxes / Stochastic	-$29,189.95 → -$22,396.39
Interest / Stochastic	-$28,679.33 → -$22,309.67
Insurance / Stochastic	-$28,621.65 → -$22,733.08

Baseline = -$26,163.82

Legend: Input High (blue), Input Low (red)

X-axis: -$120,000 | -$100,000 | -$80,000 | -$60,000 | -$40,000 | -$20,000 | $0 | $20,000 | $40,000 | $60,000

Summary:

Enterprise budgets, single point estimates, sensitivity analysis, and stochastic modelling to assess robustness are effective approaches to assess project viability. Due to the high uncertainty with new enterprises, the variety of risks and unknowns, the stochastic model can be an additional approach to hone in, and refine, underlying assumptions to prioritize areas that have a disproportionate impact on overall project viability. Future research can further inform the distributions of key model inputs and the impact to robustness of enterprise profitability and explore the decision maker's risk profile with regards to project evaluation criteria. Additionally, as on-farm co-product processing is a market-led opportunity, stochastic modelling can serve as an adaptive quantitative framework to ride the variations in market prices and market opportunities, in addition to modelling impacts of certain process improvements. While specific input values, ranges, and distributions will vary, the above examples highlight the potential for this approach to help inform project assessments.