MUDAC 2024 Challenge

About AURI

The mission of the Agricultural Utilization Research Institute (AURI) is to foster long-term economic benefit through value-added agricultural products. This is accomplished by using science and technology to help develop new uses for agricultural products. AURI partners with businesses and entrepreneurs to generate economic impact in Minnesota communities by helping businesses take advantage of innovative opportunities in four focus areas: biobased products, renewable energy, coproducts, and food. A broad range of services, including applied research and development, scientific assistance, and a targeted network of resources to develop value-added uses for crops and coproducts are provided by AURI. In the past five years, AURI's business development team and scientific staff have supported several hundred client projects and broad industry initiatives. These efforts have resulted in the creation and retention of nearly 400 jobs, and AURI clients estimate an additional 861 future jobs will be created and retained. Clients also reported $118 million in capital invested, with over $316 million anticipated in future investment and $291 million in new gross annual sales.

Background

Agriculture is the practice of cultivating natural resources to sustain human life and provide economic gain. Agriculture involves planting crops and raising animals with modern production methods and constantly emerging technologies. The focus of this year's challenge is to understand crop production and the use of various fertilizers across the State of Minnesota over time.

In 2022, the Agricultural Utilization Research Institute (AURI) investigated the fertilizer supply chain in Minnesota to identify the necessary steps for catalyzing industry adoption of alternatives to synthetic fertilizer. Synthetic fertilizers are heavily dependent on fossil fuels and are estimated to be responsible for about 1.8% of the global greenhouse gas emissions. The most important synthetic fertilizer on Earth is ammonia (NH3), and this is responsible for increasing agriculture's ability to produce enough food to sustain the current global population.[1] Synthetic fertilizers, such as ammonia, are often produced in large petrochemical complexes that are distant from the land in which the fertilizer needs to be applied which leads to increased cost and long supply chains. In addition, the reliability of these long supply chains has proven to be problematic in recent years, e.g. worldwide pandemic and the geopolitical conflict in a critical production region of Ukraine and Russia. Cost, long supply chains, and sustainability concerns have led to an increased desire to investigate the feasibility of developing new opportunities for producing "green" fertilizers in Minnesota. The production facilities for these "green" fertilizers would have a lower carbon footprint and be regionally located to take advantage of shorter supply chains. Such investments would have a positive impact on improving the environmental sustainability and economic security of the agricultural sectors across Minnesota.

One of the key findings from the AURI 2022 investigation of the fertilizer supply chain in Minnesota was that while the production of "green" fertilizer is technically feasible and current incentives make it

[1] Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org) Date accessed: May 2022

economically viable, new markets will need to be developed to maintain the desired production volume over the expected lifetime of the facility to help offset the considerable expense in building the new facility and the necessary infrastructure to support the new facility.

In addition to the potential development of new "green" fertilizers, AURI's 2022 investigation encouraged the industry to consider alternatives to synthetic fertilizers – such as biological or organic fertilizers (i.e. manure). Synthetic ammonia (NH3) has a high concentration of nitrogen and so does manure. Some estimate that making improvements to recover more of the nutrients in manure could cover nearly one-third of the demand for nitrogen in Minnesota. Thus, manure represents a valuable opportunity to reduce the consumption of synthetic fertilizer. Lastly, AURI's 2022 investigation suggests that more guidance on policy is needed, and clarity is needed to help farmers and other consumers adopt best practices in fertilizer use.

Challenge Objective

Provide an understanding of the crop production levels for the major crops (corn, soybeans, and sugarbeets) grown across Minnesota since 2010. There are several factors that are known to impact crop production levels. For example, soil quality and the use of fertilizers (synthetic or organic) in a given year are key factors in crop production levels. This year's data challenge requires that you investigate and understand the impact of these key factors on crop production. In addition, you are encouraged to consider other factors that can be shown to impact crop production levels or the rate in which various fertilizers are used in the production of these crops. Finally, this year's challenge requires the identification of *two* potential sites for new "green" fertilizer production facilities in Minnesota.

Tasks

1. Investigate the crop production levels for corn, soybeans, and sugarbeets across the state of Minnesota. Which geographic regions of Minnesota have the highest level of production for these crops?

2. How have the crop production levels of corn, soybeans, and sugarbeets in Minnesota changed over time?

3. A farmer must consider several different factors when considering what crops to plant and how much of each crop to plant. For example, the anticipation of a drought or the anticipation of higher fuel costs are likely to influence which crops and how much of each crop will be planted. Conduct an investigation into the impact of various outside factors might have on the decision a farmer must make regarding which crops to plant or how much of each crop to plant in a given year.

4. Describe the patterns in the use of synthetic fertilizer across the state of Minnesota. Investigate the variation in the use of synthetic fertilizer over time. Discuss the impact that various outside factors might have on the use of synthetic fertilizer over time.

5. The use of biological/organic fertilizers can help offset the need for synthetic fertilizer. The most readily available source of organic fertilizer in Minnesota is animal manure – from cattle, hogs, and turkeys. Investigate the patterns in the availability of animal manure to be used as an alternative to synthetic fertilizer across the the state of Minnesota. Are there regions in Minnesota for which increasing the availability of animal manure would be beneficial?

6. The soil quality is an important factor in determining crop production levels. For example, an area with higher soil quality may not require as much fertilizer to achieve the same crop production level as a second area with lower soil quality. The Crop Productivity Index (CPI) is a metric used to measure soil quality. Provide an understanding of the variation in CPI values across the state of Minnesota.

7. Provide additional insights into the complex relationships that exist between crop production, the use of synthetic and organic fertilizers, soil quality, and other important factors that would allow farmers to maximize production levels of corn, soybeans, and sugarbeets across the state of Minnesota.

Prediction Component

8. The prediction component for this year's challenge is to identify optimal locations for two proposed "green" fertilizer facilities in Minnesota. For simplicity, you should assume the main "green" fertilizer to be produced at each of these facilities is ammonia. Ammonia has a high concentration of nitrogen and nitrogen is an essential nutrient when growing corn, soybeans, and sugarbeets. You are required to submit the exact GPS location for your proposed facilities. You should carefully consider the following important factors and others when determining the optimal locations.
    - Transportation Costs: The cost of transporting the "green" fertilizer from the production facilities to the farmers that have a high demand for nitrogen.
    - Infrastructure Requirements: The availability of various infrastructures that will be required to operate such facilities, e.g. access to renewable energy, access to water sources, access to rail or high-throughput highways that will allow for the raw materials to easily be brought in, etc.
    - Etc…

Additional Considerations for Graduate Teams

9. Information regarding the amount of Class 2a Tillable land has been provided for each county. Provide insights into whether or not crop production levels are well balanced against the amount of tillable acres, the use of synthetic and/or organic fertilizers, commodity prices for crops grown, etc.

10. Investigate the impact that geopolitical conflicts have on exports of corn and soybeans grown in Minnesota. For example, what effect does a strained relationship between the US and China have on exports of corn and soybeans grown in Minnesota? What has been the effect of the

Russian/Ukraine war on the exports of corn and soybeans grown in Minnesota? What impact do these geopolitical conflicts have on the agricultural economy in Minnesota?

11. The consideration of "What-ifs": How might the demand for ammonia change if there were a two-fold increase in the recovery of nitrogen from animal manure? How might the demand for synthetic fertilizer change if the US Government imposed a 10% tariff on imports?

12. Consider additional factors beyond transportation cost and the availability of infrastructure that may be important in determining the optimal locations for the proposed "green" fertilizer facilities. Do certain regions have an increased workforce availability? Are there certain jurisdictions that are more amenable to securing the necessary permits for building and operating a "green" fertilizer facility? Etc.

Auxiliary Information

Synthetic fertilizers are commonly identified with three digits, N-P-K, where each digit represents the % in weight for nitrogen, phosphorus and potassium. One of the most common synthetic fertilizers is ammonia, which is 82% nitrogen in weight, and thus is identified as 82-0-0. This identification allows a farmer to easily compute how much of each nutrient should be applied. For example, if a farmer needs to apply 1 lb of nitrogen, they apply 1.21 lbs (1.21 = 1 / 0.82) of ammonia. If this farmer instead decides to use Urea (46-0-0) as their source of nitrogen, then they would instead need to apply 2.17 lbs (1 / 0.46) of urea.

Table A: Guidelines for the application rate (lbs/acre) of nitrogen, phosphorus and potassium for the three crops under consideration are provided in this table.

Crop	N	P	K
Corn	180	38.5	41.5
Soybeans	75	23	29
Sugarbeets	130	31	33

Table B: This table provides information about the amount of biological/organic fertilizers (manure) produced by a single adult animal for Dairy Cattle, Beef and Feedlot Cattle, Hogs, and Turkeys.

	Weight (lb.)	Manure Production (lb./day)	N (lb.)	P (lb.)	K (lb.)
Dairy Cattle					
Adult Animal	1400	155	1.01	0.52	0.57
Beef / Feed Cattle					
Adult Animal	1100	54	0.4	0.12	0.25
Hogs					
Adult Animal	300	14.8	0.17	0.06	0.09
Turkeys					
Adult Animal	10	0.47	0.0078	0.0051	0.0034