Title: Ag + Math = Calculated Sustainable Agriculture: Integrated Math 3 in Agriculture

Length of Course: Full Year (2 semesters; 3 trimesters; 4 quarters)

Subject Area – Discipline: Mathematics ("c") – Integrated Math III

UC Honors Designation: No

CTE Sector: Agriculture and Natural Resources

CTE Pathway: Agricultural Business

Grade Level(s): 9-12

Prerequisite(s): Integrated Math II or equivalent

Course Overview:
In order to make sound business decisions in the complex world of Agribusiness, students need to find ways to integrate responsible, sustainable agricultural practices that will benefit agriculture and the environment now and in the future. This course seeks to build mathematical connections in making those sound business decisions and build structure for real world applications of math. Upon completion of this course, students will understand how local, regional and global agricultural influences can translate into a process of using mathematics and statistics to analyze and drive decision making.

Course Content:

Unit 1 - Commodity Exploration

This introductory unit will focus on allowing students to gain foundational knowledge in the business of agriculture as they conduct research collecting data comparing how various factors (e.g. yield, time, and price) affect the production of agricultural commodities in their local area, state, national and international markets. Students create functions, tables, and graphs to analyze the data they collect, in order to understand how supply, demand, and other economic principles influence trends in agriculture. Students will explore the relationship between how changes in economic situations influence the mathematics and drive decision making. Students also compare the advantages and disadvantages of types of business ownership (e.g. sole proprietorship, cooperatives, corporations). Students ultimately understand and defend mathematics as a tool that can help current and future agriculturalists arrive at data-based decisions as they work later in the course to explore a specific agricultural commodity in which they will invest.

Unit 1 - Assignments

A. "Think Locally, Act Globally." - Students research the top 5 local commodities in their county or region using USDA crop reports, county data, agricultural journals or other local resources. They will utilize technology to create input and output tables for all two variable relationships (e.g. acreage vs. yield, price vs. time, yield vs. time). Specifically for the bi-variate data, they create graphs by hand or with technology and calculate line of best fit (they can identify the specific family of function for each equation as well as all the key features of those graphs including but not limited to domain and range of real-world scenario, intervals of increasing and decreasing graphs, relative maximums and minimums and end behavior) . In groups of 5, Jigsaw format, a student will choose 1 of the top 5 commodities and compare local economy data to state, national, and international economies. They will compare the viability of each commodity to the global market by calculating the rate of change for each as well as how each function is affected (find the specific k value given the translation of each market) by local data. Jigsaw groups present their research in graphical and written form, and students use group data to drive their individual decision as to what commodity they choose to produce. Each student will submit in written form a justification for their commodity choice.

B. "The Price is Right, or Is It?" - Students research the current market price along with the quantitative supply and demand of their chosen commodity. Using existing supply and demand data for their chosen commodity, students plot a system of inequalities. The system of inequalities will be written and graphed based on the assumption that the quantities in which demand meets or exceeds supplies can be defined. Using a graphical representation, students identify the region of their graph that represents this profitable farming spectrum, where demand meets or exceeds supply. Students then report current market value and locate its position on the graph. Students will then determine and explain if the current market value falls within the specified acceptable production region of their system of inequalities graph. Understanding and reporting on the circumstances that would move them in or out of the viable graphical region, they will brainstorm ways to add value or reduce cost to their product so that it is in alignment with at minimum the equilibrium point or the point where supply is keeping up with demand.

C. "Own It!" - Students will produce a Prezi that explores the world of Agribusiness in America's Free-Enterprise system. Students will use online sources to investigate one form of business ownership (sole proprietorships, partnerships, corporations, franchises, and cooperatives). The Prezi will include advantages and disadvantages of the business ownership they selected, an assessment of liability, financing, and economic factors that influence the owners, and examples of the types of agricultural businesses that are common within that ownership style. Students will present their Prezi to the class.

D. "To be or not to be..." - Students will conduct an interview of a farmer or rancher in their county that produces their chosen commodity. Students will develop interview questions reflecting the business and management decisions addressed in assignments 1-3 ensuring they ask questions to collect data directly relating to the bi-variate data they graphed in Assignment #1(whether it be acreage vs. yield, price vs. time, yield vs. time). Next, they will compare their research data, equations and tables with the actual farmers information. Students will graph how the actual farmer determines his decision making on the bi-variate information and graph the farmers line of best fit on the same graph(coordinate plane) as Assignment #1. The student will mathematically identify the

equation transformation from the farmers data to the data developed in the first assignment. Then, they will summarize the consistencies or differences between the two lines and possible reasons for any discrepancies of shifts. In the culminating project, each student will compile this data to use as evidence during a socratic seminar where they discuss and defend(using their math tools) why making sound mathematical decisions in farming might benefit you as a business owner. Through this seminar process, students will understand that sometimes making more informed data driven decisions will result in a change in practice for the better.

Unit 2- Ag Mechanics

Once students have completed the extensive research and data analysis they perform in previous units, they move on in this unit to utilize modeling with geometry to visualize relationships between 2D and 3D objects, in order to first create sketches and then a scale model of a facility to house/produce their agricultural commodity. Students understand the kinds of materials that go into facility design, and the characteristics of different facilities given a specific agricultural commodity. In their sketches and models, students calculate such things as perimeter, area and volume as well as polynomial shapes to maximize use of space and longevity for their facility and minimize overall cost.

Unit 2 - Assignments

A. "One flew the coop" - Students will design and lay out an agricultural facility common to the area. In preparation they will research at least 3 local agricultural facilities to identify their average dimensions. Utilizing in-person research and Google Maps, students will calculate the average surface areas of the three facilities. Students will calculate the maximum and minimum inequalities for the dimensions available. Students will use CAD designs or graph paper to scale plot their unique designs for area and volume. Students will include a brief written justification of their layout with the actual design, along with evidence of the mathematical principles they used to achieve the correct dimensions.

B. "Don't be so materialistic" - Students will investigate the most practical and economical choice of materials and then create two bills of materials for the facility they designed in the previous assignment. Students will conduct research to investigate two possible material types for their facility (e.g. using square vs. round steel tubing to build a sheep pen) as well as account for construction costs. Students will produce a side by side comparison of the two options using geometric properties to describe the shape of their enclosure (or a combination of shapes put together), use appropriate units of length and quantities, and clearly list all assumptions used to mathematically justify their total cost for the two different builds. Finally, they will make a recommendation for construction in a format determined by the teacher. Once a selection has been made, students will enter costs in the I-Record Book to continue the practice of accounting. Students will create systems of equations for their cost analysis to minimize waste (eg. board sizes in 20" or 8" sizes when 46 feet are needed).

C. "Bob, the Builder" - Students design and build a scaled model of their facility using the research of the previous assignments. Students will use scale to determine the proper ratio model while using appropriate units. Students will show all calculations to

accompany their model. (e.g volume, density, etc.) Students will also calculate the quantity of product to be housed based on the dimensions chosen. Students will present their model and defend their decision making process to the class and/or local experts or agriculturists, including research, layout, costs, and the mathematics that were used to make those decisions. Students will also critique their model and give future recommendations for future replication of the project. Students will determine if their model is consistent with their results based on the calculated materials costs. Finally, students will determine the depreciation schedule for the facility over ten years and derive the formula for the sum of the infinite geometric series.

Unit 3: Natural Resources and Agriculture Sustainability

This unit focuses on providing opportunities for students to gain a solid understanding of the economic implications of choices related to implementing various sustainable farming practices. Students understand how changing real world parameters affect the mathematical functions and can be accurately translated into a transformed equation. Students use statistical measures such as mean and standard deviation to compare if there are statistically significant differences of two different methods of farming. Students become familiar with current and emerging sustainable practices within the Agriculture industry and assess the potential costs of implementing these practices. Students will enter their data from each assignment in the I-Record Book to continue the practice of accounting.

Unit 3 - Assignments

A. "Caught in the Web" Page - Students develop analyses of several sustainable farming practices in order to identify benefits and challenges for implementing these practices in a farming operation. Working in small groups, students will research and create an informational page for a specific sustainable farming practice (e.g. organic, cover crops, more legume incorporation, intercropping, alternative/reduced tillage, beneficial pests or integrated pest management systems). Research will include information regarding how the method influences soil fertility, ecosystem balance and diversity, and disease susceptibility, while potentially decreasing the reliance on chemical inputs.
Students will produce an electronic infographic with research, written and graphical, about the practice and post to the class webpage for students and local producers to access in order to help make decisions about which practices are best for implementation. Students will then go to the website and participate in an online discussion board, commenting on their peers' findings and evaluating the different sustainability practices and options. Students will then choose which of these sustainability practices they would be interested in implementing for use in the next assignment.

B. "It's All in the Details" - Students will select one of the sustainable practices from Assignment 1 for a local commodity, and complete a detailed cost analysis developing a hypothesis regarding whether or not that sustainable farming practice will be viable. Students will use existing data for traditional farming to formulate cost based equations and potentially simulated data for sustainable farming using similar variables to compare the two treatments. They will use this statistical data comparing the mean and standard deviation of both methods and estimate to make an informed decision regarding

whether or not this sustainability practice is viable for their agricultural business and to make decisions about how much they would have to charge consumers for their commodity in order to afford to implement this sustainable farming practice. Students will submit a 1-2 page written summary of the practice they chose detailing whether or not it is a viable option for a local commodity and include mathematical data to justify their reasoning.
Resource Simulation explanation and tool:
http://www.creativeteachingsite.com/edusims.html

C. "Buy this, not that" - Students will create a marketing commercial (approx. 3 minutes) using the sustainable quality of their product as one of its selling points. Students must include a rationale of why consumers should support and purchase food from farms that use sustainable practices and pay for the more expensive food items, regardless if they found if the practice is financially viable. The rationale should include a random sample survey that compares sustainable versus traditional products in a way that helps people decide that sustainable is preferable. The student will design the sample survey or experiment to provide statistical evidence embedded in the commercial showing the advantages of a sustainable product.

Possible extension:
Students will develop a single survey question (e.g. - "Do you support sustainable agriculture products even if they result in higher prices?" or "Organic or Conventional Food"). Students will develop a hypothesis and test it at a local grocery store by asking the customers the question as they walk in. Students will analyze the data to determine if there is statistical significance in the consumer decision regarding sustainable agriculture. This assignment will allow students to gain perspective about the community and whether or not implementing sustainable practices (and thus possibly increasing prices) will pay off in the long run for agriculturists.

Unit 4: Plant Science

Students will develop a process that will prepare them to make mindful sustainable choices for future farming. In this unit, students will experience a process where they demonstrate responsible farming, decision making, and how to implement those practices. The process will begin with developing a plan for an orchard through learning about risk management and risk contingency plans as they apply to the field of agriculture management. Students gather data from cyclical weather plans and conical sprinkler models and use this data to develop and implement an action plan for cost and energy efficiency. This data shall be obtained using but not limited to the different organizations (e.g. Farm Bureau, USDA, UC Extension Service, etc.) involved in agriculture. Upon completion of this unit, students will be able to make sound, sustainable business decisions through mathematical applications and justifications.

A. "See the forest through the trees" - Students will be given a one acre plot of land and a tree species (or other crop that would utilize sprinkler irrigation). Students will research and develop a list of criteria that influence their planting choices (eg. chemical application, harvesting, equipment usage in orchard, crop yield). Based on criteria choices, students will select a spacing plan to maximize production, yield and plant

health without compromising soil and ecosystem health. Students will then determine the quantity of trees and produce a scaled plot of the trees within that acre. Student present final product and justification of their decisions.

B. "Let it Rain" - Using the plot plan from Assignment 1, students will create 2 separate sprinkler plot overlays and calculate the most cost-effective, sustainable, and energy saving option. The first design will be based on a circular/semi circular sprinkler head radii and the second will be based on a hyperbolic sprinkler head spray. Students will understand the elements of conic equations, translate that information into an appropriate conic equation and use the appropriate terms to inform the sprinkler mechanic of pressure specifications in order to minimize water waste. Using the 2 sprinkler options, students will complete a cost comparison of the materials needed to implement each option, using the respective conic equations to justify the sprinkler head quantity and positions, and write a proposal for choosing one of the sprinkler patterns.

C. "Sunny Side Up" - Students will explore solar energy as an option for supporting more sustainable decision making in orchard management.
They will model periodic phenomena of capturing solar energy with a specified amplitude, frequency and midline for their demographic area. Students will also write the equations in both radian form and angle form in order to predict specific terms associated with a periodic function and identify the graphical midline in order to calculate the average annual solar absorption kilowatts and the associated cost savings.
Students will present mathematical data that was used to derive their periodic function. They will then use this function to calculate the return on investment timeframe for the solar structure.

D. "Catch it Quick" - Students will be presented with two separate scenarios of catastrophic events that could affect their orchard. For each scenario, students will develop exponential decay equations and develop their corresponding logarithmic inverse equations understanding that a logarithmic equation undoes the corresponding exponential function. Using the logarithmic equations students will then determine the timeframe to implement a method to save their orchard.
Using the calculated time frame found in the logarithmic equation, students will develop a risk management plan to evaluate preventative and reactionary options that address pest/disease outbreaks. The written plan will compare preventative options (eg. crop rotation, fertilizer usage, removal of diseased plants, time of planting) and their associated costs to reactionary measures (e.g. chemical application, crop eradication). This plan will include graphical representations of how the preventative and reactionary options mathematically build a new function from an existing function. Students will identify a clear understanding of how the graphical shifts affect the mathematical functions.

The risk management plan will also include research based statistical probability of one disease/pest outbreak and determine the break even point between the preventative measure and a reactionary measure.

Resource:
http://plantdiseasehandbook.tamu.edu/problems-treatments/methods-and-materials/cultural-practices-for-reducing-crop-diseases/

Unit 5: Animal Science

Students will develop a detailed plan to advise a rancher regarding responsible livestock production, management, and marketing practices. In this unit, students will complete an analysis of two different livestock production practices by determining the difference in fixed and variable costs; estimating the profit yield and break even costs for these practices; and determining economies of scale using mathematical principles and graphical demonstrations. After determining the best practice from these options, students will then explore possible sources of credit for the rancher's operation; use expressions to prove which form of credit will be the most advantageous for the operation; and then complete an application for the determined credit source. Concluding the unit, students will investigate the local, national and international markets for the livestock species, including government influences, economic data, cultural values and trade policies. Using this data, students will select a market and develop a marketing plan to assist the rancher in selling his stock responsibly and profitably.

Unit 5 - Assignments

A. "Home On The Range, and Domain" - A local rancher is trying to decide between two comparable practices in livestock production. Students will identify fixed and variable costs associated with production and management of these different practices (e.g. grass fed vs grain fed, organic vs. conventional, hormone or non hormone use), and write an expression for the total cost clearly listing all assumptions used in determining these costs. They will then create tables and corresponding polynomial functions for the data collected, plot both options on a graph and identify the break even point at which both options would yield the same profit. After locating the current local market price students will summarize if either option is viable in today's market. Students will then determine at which production level economies of scale are achieved, identifying specific domain and range values for each scenario. Finally, students will acknowledge and use the mathematical differences to advise the rancher about which practice to adopt through a proposal format of the teacher's choice .

B. "Give Credit, Where Credit Is Due" - On behalf of the rancher from assignment one, students list all fixed and variable costs associated with the production options. Using the current market loan rate from your local bank, students will investigate concrete examples of geometric series using the current loan rate. They can use spreadsheet software to generate the pattern of growth of a loan and learn to express that sum of the geometric series with a single exponential equation. This exercise will link the concept of a mathematical pattern to a complex equation and then students can use that equation to calculate solutions to a variety of different questions about the loan such as total owed, monthly payout, time of loan etc. Students can also repeat this process to compare two different loan types or rates and develop the corresponding exponential

equations for the new type of geometric sequence and compare research options to justify the most affordable credit source. Students will organize and report their work in a document and explain how the mathematics drove their loan choice. Once the credit source is chosen, students will complete a loan application to obtain financial assistance. Students will determine the source of credit to pursue and the advantages of these credit sources

C. "Is the world only six degrees of separation?" - Students will research the local, national, and international markets of the livestock specie used in assignments one and two. The research will include an analysis of governmental influences, economic data, cultural values, and current trade policies that affect the trade of their commodity. Students will select one market to sell their livestock product to (e.g. local, state, national, or international market) and develop a marketing plan for their product outlining how they will sell their product to the selected world market. The marketing plan should include any mathematical limits to their data, either their dependent or independent parameters (variable domain and range). The marketing plan will solidify their knowledge of how math is applied to real world situations and the limitations of that math in decision making.

Culminating Project - "Shark Tank- Ag Style"

Students will work in small groups and use resources from previous units to select a commodity that, if added to their community, would flourish. They will then plan to implement a fictitious farm/ranch and create a complete business plan for their proposed commodity. This business proposal will be presented to a panel of "investors" (local experts, teachers, community members, parents) who will decide which group is worth investing in.

Students will answer the three economic questions (what will you produce? how will you produce it? Who is the product intended for?) in their business plan using data, written reasoning and research, and mathematical justification. Students will justify the choice of their commodity using historical data, supply/demand data, and current market prices. Students have practiced several mathematical tools and representations of displaying data. In this final assignment the student will be able to choose specific tools strategically to sell their idea to the investors; for every tool they choose, they will need to be explicit with what family of functions their data is associated with and the correlation coefficients that justify that family. The business plan will include: overall strategy and business ownership structure, cost breakdown and plans to acquire financial backing, predicted production outcomes, and marketing and management strategies. Again, this business plan provides ample opportunity for students to model real-world agricultural data in a variety of ways. This course highlights the importance of choosing and using mathematics and statistics to analyze real world situations, to understand them better, and to make sound decisions using math. In the marketing portion of the business plan, students will determine their target market, competitors, and sales and advertising strategies that will be used. For management strategy options, students will select at least two similar production practices from previous units. Options include but are not limited to: sustainable farming/ranching practices, irrigation options, energy sources,

disease and pest prevention programs, and facility requirements and design. They will then justify how these business decisions will result in sustainable and profitable outcomes.

Students will enter all financial and loan projections into the appropriate documents in the I-Record Book. Further, these accounts will be transferred to compatible tax programs enabling students to determine the tax obligations for their agribusiness. Students will compile all components of the business plan into a cohesive written report that also brings together all of their experiences with functions and geometry to create mathematical models and solve contextual problems. This business plans serves as a demonstration of their understanding of modeling and they will compare models by analyzing appropriateness of fit and make judgements about the domain over which a model is a good fit and how that data supports their proposal. Finally, students will pitch this business plan to the aforementioned "investors". Students are encouraged to use prototypes and visual aids to assist in their presentation.

Course Materials:

Title: Agricultural Economics and Agribusiness (ISBN 471-38847-5)
Edition: 8th
Publication Date: 1979
Publisher: John Wiley & Sons
Author(s): Gail Cramer, Clarence Jensen, Douglas Southgate
Usage: Primary Text; excerpts used as a textual source for graphing and background understanding.

Title: Introduction to Agricultural Economics (ISBN 13-159248-3)
Edition: 5th
Publication Date: 1996
Publisher: Pearson
Author(s): John Penson Jr.
Usage: Primary Text; excerpts used as a textual source for graphing and background understanding.

Supplemental Instructional Materials:

Unit 1 - 5: (Resources With Applications For All Units):

Agricultural and Resource Economics: http://coststudies.ucdavis.edu

California Ag Education: http://www.calaged.org/

California Department of Agriculture: http://www.cdfa.ca.gov/

California Farm Bureau: http://www.cfbf.com

California Math Framework Document: Mathematics 3:

http://www.cde.ca.gov/ci/ma/cf/draft2mathfwchapters.asp

Capital Press Weekly: http://www.capitalpress.com/california

Engage NY Common Core Math Lesson Resource:
http://www.engageny.org/mathematics

Graphing calculator: https://www.desmos.com/calculator

Excel: spreadsheet for collecting data and calculating line of best fit with equation and correlation coefficient

Create a Graph:http://nces.ed.gov/nceskids/createagraph

Kahn Academy Tutorial (Math) : https://www.khanacademy.org/coach/dashboard

National Agricultural Statistics Service: http://www.nass.usda.gov

National Society of Professional Surveyers: http://www.nsps.us.com/inde

XP Math: http://www.xpmath.com/careers/jobsresult.php?groupID=6&job

Mind Tools: Supply and Demand:
http://www.mindtools.com/pages/article/newSTR_69.htm

Commodities graphs: http://futures.tradingcharts.com

Production posssibility curves:
http://www.businessdictionary.com/definition/production-possibility-curve.html