U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA)
Research and Extension Experiences for Undergraduates (REEU)
Research and Extension Experience in Energy and the Environment across Agriculture Disciplines (RE^{2}AD)

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Research Project List

Project #1: A systems approach to improving learning and dynamic decision-making capabilities in agricultural and natural science professions

By Dr. Benjamin Turner, Assistant Professor, Dept. of Agriculture, Agribusiness, and Environmental Sciences

i. Motivation: Much research across disciplines has shown that people typically perform poorly on dynamic decision making tasks. This is especially troubling for agricultural and natural resource sciences, where systems are inherently complex due to their biologic, geologic, socio-economic, and climatic characteristics. The objective of this project is to better understand the causal mechanisms and perceptions that drive learning and management in complex agricultural and natural resource settings that lead to reinforce poor performance on dynamic decision-making tasks.

ii. *Project Description*: This project consists of two major activities: 1) conduct a series of decision-making intervention experiments to test dynamic decision making performance of students in agricultural programs versus professional managers in agricultural industry; and 2) using journaling methods and written survey analyses, link participants' feelings and reactions recorded during the experiments to identify mechanisms that led to or reduce successful task performance. In the experiment, participants will make decisions in response to a dynamic task management problem using a computer simulation model. Quantitative data from participants' decisions will be recorded for statistical analysis of performance based on task, feedback, and intervention type. The data will also be used to parameterize decision-rules used by participants to identify which variables and feedback processes were most relevant or important to their decision-making. Participants will also keep a journal during the simulation to log their decision strategies, feelings, thought processes, etc. Journal entries will be coded for critical themes and factors used to navigate decision-making tasks, and will be correlated with the quantitative results.

iii. *Undergraduate Research Opportunities*: Two REEU students will work on this project. Both students will assist with recruiting participants, setting up and running the experiments. One student will focus on analyzing quantitative experiment data, while the other student will focus on analyzing qualitative journal entries data. Both students will check for potential correlations in their results.

Project #2: Modeling Surface-Groundwater Fluxes and Quality in a Region Dependent on Precipitation for Dryland Cropping Systems

By Dr. Jianhong Ren, Professor, Dept. of Environmental Engineering

i. Motivation: South Texas has long been a giant when it comes to crop production with farming and ranching being major contributors to the local economy. Despite the economic importance of crop production, cropland in the South Texas has been decreasing. This project will use process-based models to investigate the relationships among climate variables, land use types, and surface water and groundwater fluxes and quality. The objectives are to 1) examine the effect of land use changes on the

surface water-groundwater (SW-GW) interaction under changing climate, 2) determine the effects of seasonal crop rotation on the SW-GW fluxes and quality, and 3) determine how considering SW-GW fluxes will improve the estimation of soil moisture under changing climate, land use, and agricultural activities.

ii. Project Description: The project will use the Coastal Bend Regional Water Planning Group (Region N) as a testbed, which includes portions of three major river basins, i.e., Nueces River Basin, Nueces-Rio Grande Coastal Basin, and San Antonio-Nueces Coastal Basin. Separate models for each basin that link surface water processes and groundwater processes will be developed using SWAT–MODLFOW coupled model and modified to include reservoir-aquifer interaction. The basins will be delineated, i.e., divided into sub-watersheds, by either considering elevation, streams, and the general boundary of each basins, or using 8/10/12-digit Hydrologic Unit Code from Watershed Boundary Dataset at United States Geological Survey (USGS). Model input data such as Digital Elevation Model, soil data, precipitation data, and crop rotation information will be obtained from various sources. The model will be calibrated using streamflows measured by USGS control points and groundwater heads measured by Texas Water Development Board. Future climate conditions impacts will be evaluated using downscaled climate projections under different greenhouse gas concentrations.

iii. Undergraduate Research Opportunities: Two REEU students will work on this project. Both students will compile surface water and ground water quality data, agricultural information, land use types, and climate data of Region N. One student will focus on conducting preliminary data analysis to examine trends and possible relations among climate variables, land use types, and surface water and groundwater quantity and quality. The other student will focus on identifying data gaps for improved regional water and agricultural resources management.

Project #3: Self-Sustained Energy Supply with Renewable Energy for Farm Operation

By Dr. Hua Li, Professor, Dept. of Mechanical and Industrial Engineering

i. Motivation: Farms are vital to sustaining rural jobs and economies. More than 85 percent of U.S. farms are small and 50.1% of farms have economic sales lower than $10,000. Energy consumption is costly for individual farmers in rural America. Unstable energy prices and electricity disruptions cause more harms to farmers. This project aims to promote renewable energy (wind energy, solar energy, and renewable biomass) by creating a comprehensive framework for assessing hybrid renewable energy potential and its application on supplying energy for farm operation through data collection, data visualization and feasibility analysis.

ii. Project Description: The possibility to combine different renewable energy sources as a hybrid energy system is of great interest because it would increase energy output significantly while creating positive synergies and reducing variability. Four major tasks will be completed: 1) Data collection. Solar radiation data will be obtained the National Solar Radiation Database while wind data will be obtained from the Climate Forecast System Reanalysis. Biomass data will be obtained from the "2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy" from the Department of Energy. 2) Data visualization. A big data analytics based visualization platform will be created using Geographic Information Systems (GIS) based computer animation in MATLAB. The platform will be able to dynamically visualize the collected data and conduct statistical analysis to explore and assess the hybrid energy potential in Texas. 3) Conduct technical and economic feasibility analysis on the application of the hybrid energy system in a given farm in Texas.

iii. Undergraduate Research Opportunities: Two REEU students will work on this project. Both students will work on data collection. One student will focus on 1) converting collected data into images using GIS tools, and 2) creating a GIS animation based visualization platform with statistical analysis function in MATLAB. The other student will focus on conducting 1) technical feasibility assessment considering

positive synergies of hybrid energy systems, and 2) economic feasibility assessment considering lifecycle economic analysis.

Project #4: Sequential activation of nontraditional crop products for the production of engineered adsorbents for water quality improvement applications

By Dr. David Ramirez, Professor, Dept. of Environmental Engineering

i. Motivation: The production of engineered activated carbon adsorbents from nontraditional crops such as dried beet pulp can provide environmental and economic benefits. Dried beet pulp is a co-product of sugar beet processing and a widely used compound feed ingredient for animals. Beet pulp contains an important amount of structural carbohydrates that makes it attractive for activated carbon production as adsorbents to improve water quality. This project proposes an integrated method that combines carbonization with sequential physical and chemical activation to produce crop-derived activated carbon (CDAC) that has not been explored before and has the potential to produce high quality adsorbent materials.

ii. Project Description: This project's objectives are to 1) prepare new engineered CDAC adsorbents through a sequential activation of carbon dioxide (CO2) followed by water vapor activation using alternative crop products such as sugar beet; 2) assess the effects of physical, chemical and sequential activation methods on the surface area, porosity, pore size distribution, bulk density and electrical resistivity of the adsorbents; 3) assess the application of the CDAC for water quality control; and 4) assess the reliability and reproducibility of the sequential activation on the physical and electrical properties of the crop-derived adsorbents using statistical tools. Dried beet pulp will be shredded to a size of 0.4-10 mm, and will then be carbonized in a bench-scale horizontal 3-zone tube furnace fitted with a 3 inch-ID ceramic reaction tube under ultra-high purity N_2 with a gas flow of 0.5 L/min. Carbonized samples will be then activated with a sequential activation first in CO2 followed by water vapor activation. More samples will be activated by a physical method using steam and a chemical method using phosphoric acid activation for comparison. The CDAC will be physically and chemically characterized for the uptake of water pollutants.

iii. Undergraduate Research Opportunities: Two REEU students will work on this project. Both students will learn the carbonization and activation processes for the manufacture and characterization of CDAC. One student will focus on the sequential activation method using CO2 and water vapor while the other student will do the physical and chemical activation using steam and phosphoric acid. Both students will then integrate their results to assess optimal conditions for producing a high quality CDAC.

Project #5: Using Engineering Economic Analysis Methods and Tools to Evaluate Farm Efficiency, Profitability, and Uncertainty

By Dr. Kai Jin, Professor, Dept. of Mechanical and Industrial Engineering

i. Motivation: Improving farm efficiency and profitability has been a challenge in the decision making process especially for small and medium sized farms. The usage of modern high tech communication tools generated more data and information which can be used to in the decision making process. However, there is lack of a systematic platform can help the user visualize and effectively use the data. This project will train the students to use engineering economic analysis methods and tools on the available big data on agriculture to generate the valuable information for the decision making purpose.

ii. ***Project Description***: Economic analysis is based on a comparison of discounted costs and benefits over a fixed time period of time. Alternatives can be summarized in terms of the ratio of total benefits to total cost or equivalently and the total net benefits. Goal seeking and sensitivity analysis will be used to address

the uncertainty in the problems. Students will be trained to use these approaches on agriculture applications especially small and medium size farm operations. After defining their own research questions and objectives within the scope to improve farm efficiency and profitability, students will identify feasible alternatives for accomplishing the objectives. Economic analysis methods and techniques to handle uncertainty and risk will be applied on the compiled data. Students will compute a measure of economic performance, compare the economic consequences of alternatives and make a decision considering any non-quantified effects and decision maker's risk attitude.

iii. ***Undergraduate Research Opportunities***: Two students will work on this project. They will start together with the data collection mainly from USDA NASS website. Students will be trained with present value analysis, rate of return analysis, benefit to cost analysis, sensitivity analysis, etc. Each student will implement different methods and tools on the collected data, and evaluate the effectiveness and efficiencies of these methods and tools on agriculture applications.