Information, Modeling, and Analysis – Project 3 (formerly Projects 3 and 4) Year 3 Annual Report

Middleware and Adapt Biophysical Models for Integration in the Foreign Animal and Zoonotic Disease Defense Support System and Collaborative Grid Computing System

DHS Priority Areas Addressed	☒ Prevention	☐ Detection	☒ Response	☐ Recovery	☐ Education/Risk Communication
Proposal Section Addressed	Sections 5.1.2 and 5.3.3				
Investigators	TAMU: Rahahavan Srinivasan				

Objectives	Deliverables	Progress Toward Deliverables	Percent Complete
Task 1 - Middleware and Grid Computing			
To analyze the system structure of critical biophysical models (PHYGROW, SWAT, EPIC, NUTBAL) and develop a mechanism for easing integration into the FAZDD Decision Support System.	PHYGROW diet quality module		
	Complete algorithm design	An accumulated heat unit algorithm was selected for testing in the model based on an extensive literature review.	90
	Code and test against validation sets	A test module for the concept has been coded and a validation study initiated to test the algorithm against fecal NIRS scans of grazing livestock and weight change in the livestock to determine of the algorithm performs within biological tolerances. A Ph.D. student was assigned to this aspect of the project.	50
	Make model downloadable on the web		0
	NUTBAL reproduction module		
	Complete algorithm design	Based on industry surveys, extension datasets and published literature, a pregnancy rate algorithm was developed that accounts for body condition (1 to 9 system) at three stages of production (birth, breeding, weaning) as well as percent animals missing pregnancy in past.	100
	Code, validate, and implement on the web	The application is coded validated against a study conducted by the Texas Extension Survey involving over 800 mature cows and the prediction was acceptable in the 3 to 7 body condition range where most observations occurred. The application has been embedded in the standalone and web version of the NUTBAL PRO nutritional balance analyzer	100
	Linkage module with NUTBAL		
	Complete algorithm design	A preliminary design as been made but cannot be completed until the nutrition algorithm has been tested.	20
	Code and implement on the web		
	SWAT carcass disposal component		
	Complete algorithm design	The addition of the SWAT carcass disposal algorithm has been completed.	100
	Update code of model	Coding of the carcass disposal module in SWAT has been completed.	100
	Run analysis for carcass disposal analysis	There have been several test analyses run in conjunction with the economic studies being conducted in project 10.	80
	EPIC data storage structure redesign		

	Complete algorithm design	An improved storage structure was redesigned	90
	Code and implement	Coding and testing of the improved storage structure was completed but will require further testing once specific scenarios have been selected for analysis.	90
	Prepare middleware design and performance document		
	Conduct literature review	Progress for middleware development has gone slowly due to the need to get key staffing on some of the modeling teams and develop workplans with other collaborating institutions.	70
		We were fortunate to have the ISI Risk Analysis Workbench team from the CREATE center join efforts in FAZD where they are pursuing new middleware concepts for systems integration. Also, the group from the simulation exercise specialists at Texas A&M engineering school have provided insights from their experiences of integrated systems for training first responders in homeland security, global situation awareness tools for the US Air Force and other tools developed for the Department of Justice. We determined systems requirements and began building code for integration of an epidemiological, transportation, and economic models	65
To develop appropriate middleware that facilitates varying degree of data coupling between modeling components of the FAD-ZD Decision Support System.			

		A conversion of the AusSpread model from MapBasic to Java was done to make AusSpread more functional in a distributed computing environment and to enable front end and back end data integration as well as linkages to the other models. Add	40
	Test alpha version	Alpha version without back is near completion.	10

	Task 2 - Collaborative Grid Computing System		
Develop a grid computing system network that supports multi-location computation in FAD-ZD defense.	Deploy collaborative grid computing system	GRID computer systems have been setup and used on various sub projects. These systems have speed up the simulation process to great extents.	100%
	Complete assessment of GLOBUS	Done	100%
	Set up hardware	Done	100%
	Test GLOBUS concept with UCD, USC- ISI	Done. After assessment and discussions, the option of using GLOBUS to directly submit jobs to remote site seems is the not the best one for the concerns of access control, security and other issues. Instead, a new option to use web service interface to connect different collaborators is proposed and tested. This option avoids the requirement of opening ports on firewall, setting up accounts for remote accessing, and other issues.	100%
		In progress	NA

Highlight for Research Briefs

Interpretive Summary

A suite of existing biophysical models have been brought into the FAZD tool kit after being proven to support the broad areas of forage, animal and hydrologic response. However, it was recognized that some of the tools required minor changes, addition of key modules or restructuring of the databases that support them to be compatible with a more integrated computing environment that is required for FAZD activities. Therefore, we have focused on some of the more important biophysical models in the FAZD tool kit. The SWAT hydrology model is the foundation model for all the environmental studies and required a new module to better accommodate the issue of carcass disposal analysis conducted in project 10. The module was successfully added to the model and analysis was able to be performed for other studies emerging in project 10. The PHYGROW plant growth model is a comprehensive grazingland production model and a gap was identified in the need to simulate diet quality of animals that graze in the model to allow prediction of animal performance. A heat-unit concept was devised based on extensive literature review to help the model to "age" plant tissue to then allow computation of realistic crude protein and digestible organic matter content of diets selected in the model by grazing animals. A validation trial was established in 2005 and is currently underway to test the algorithm. A gap in the nutritional balance analyzer (NUTBAL PRO) was identified that required improvement of the pregnancy rate calculator. A new algorithm was designed, tested against independent datasets and implemented that allows pregnancy rate predictions of herds based on body condition score, timing of the score relative birth, breeding or weaning and percent of the herd that has missed calving in a given year. A major task area that has been initiated is the development of middleware language to integrate critical models to form more unified analysis environments. A review has been made of various middleware options, and an initial design for linking an epidemiological model, the transportation model, and an economics model has been developed. In collaboration with the USC ISI Risk Analysis Workbench team, we have worked to develop a Common Modeling Environment to integrate FAZD and other Center of Excellence models. The development of appropriate middleware is a key component of this effort.

Results and Interpretations

The primary objectives of Project 3 are to 1) upgrade and improve existing biophysical modeling tools required to support both environmental and economic analysis and 2) develop reusable middleware techniques to integrate a variety of modeling and spatial tools emerging within the IMA theme area of FAZD.

The PHYGROW plant production model is a robust, multiple plant:multiple animal forage production model. It can represent grazinglands of any type in terms of forage production, runoff, deep water recharge and animal diet selection. Given the emphasis on livestock diseases and animal response, a gap in PHYGROW was identified in the model that could potentially limit its use in the FAZD arena – estimation of diet quality of grazing animals. The model can predict the composition by weight of different forage species in various stages of growth that comprise a target animal's diet. Therefore, the challenge was to design a new algorithm that could translate the growth status of the plant material consumed by animal (x) into weight of crude protein or digestible organic matter consumed each day. If the intake and diet quality are known, then another model in FAZD's toolkit can translate that into animal performance for cattle, sheep and goats. After extensive literature review, we found that a heat unit concept would be useful for aging the tissue grown in the model. Essentially, for a given plant species, a start day was specified and the base temperature for the species was then compared to average daily temperature over time. A mathematical equation was then developed where maximum tissue density of crude protein and digestible organic matter was adjusted by heat units accumulated to date(x). Bench top tests were completed that resulted in reasonable results. However, a control grazing trial was established where the stand was modeled in PHYGROW, and the fecal material of a herd of steers was collected to determine crude protein and digestible organic matter in the diet. The animals were then weighed and compared to the modeled predicted weight change in the NUTBAL PRO nutritional balance analyzer. This trial was completed in July 2006. The data are currently being analyzed and if acceptable, the algorithm in the test model will be fully integrated into a new version of the PHYGROW model.

Because the NUTBAL PRO model targets individual animal response, there was an additional need or modeling gap recognized that needed to address reproductive success at the herd level in response to forage conditions, weather, physiology and management inputs. A pregnancy rate module was researched, designed, coded and implemented that provides the estimation of herd level pregnancy response with a minimal data set. Essentially, the pregnancy rate module allows allocation of animals into each of the nine, standard body condition score classes by stage of production (birthing, breeding, weaning) and an assumed percent of cows that do not give birth in a annual production cycle. Completion of the diet quality module in PHYGROW and the pregnancy rate module in NUTBAL PRO will allow positioning of these models into the FAZD modeling toolkit to serve emerging needs for animal performance and production analysis and to better serve the economic modeling component.

The SWAT basin-scale hydrology model forms the backbone of the environmental modeling along with the EPIC and PHYGROW models. An emerging gap was identified as we began conducting the carcass disposal study with project 10 that is investigating the economic and environmental impact of carcass disposal

issues associated with the outbreak of foot and mouth disease. SWAT did not have a mechanism to represent impacts of carcasses placed at different locales and use of various intervention techniques to fully capture the effects in the model. Therefore, a new module was designed, coded and implemented that allows the model to capture both the effects of location in the watershed and the treatment impacts on water flows as well as chemical/microbial flows.

The EPIC crop production model only underwent some minor changes in the database structure of the program to allow a more robust coupling with various system configurations when the time comes to use this well established model.

The other major objective of this project addresses is the development of middleware that allows efficient integration of modeling tools into a decision support system framework. Our initial efforts have focused on developing middleware to allow integrated data input, communication, data passing, and common mapping and visualization tools for an epidemiology, transportation, economic and biophysical/environmental models (Figure 1). Specially designed middleware would be developed to allow this integration to occur. For our initial test of this concept, we chose to work with the AusSpread epidemiology model being evaluated in Project 11 and to link it to the transportation model (Project 11) and to the economic model (Project 12). Because the current version of AusSpread is written in MapBasic for MapInfo, it is not very scaleable on a distributed computing system. Therefore, the model was rewritten into JAVA so that it would be scaleable and to take advantage of JAVA's capabilities to be programmed for transferring data to relational and GIS databases. At the present time, the AusSpread model has been coverted to JAVA and middleware linkages are being programmed to allow data inputs to be transferred from a database or web interface. Backend middleware is also being developed to allow transfer of model output to databases for visualization and the combining of other model outputs. Data transfer and internet mapping algorithms are being developed so that model outputs can be combined with base cartography layers (roads, administrative boundaries, rivers, etc) to give spatially explicit representation of the data. This work will be expanded in Year 3 to include other epidemiological and the biophysical models.

Another major component of this effort has been the work with the USC-ISI team to expand the Common Modeling Environment (CME) framework. A draft white paper was developed by USC-ISI that provide the design specifications and requirements for the Common Modeling Environment The CME will consist of tools that allow researchers to "link" data, models, and decision-support tools into composite systems used to address risk-based problems. Much of the middleware being designed to integrate the FAZD models will be a key component of this effort.

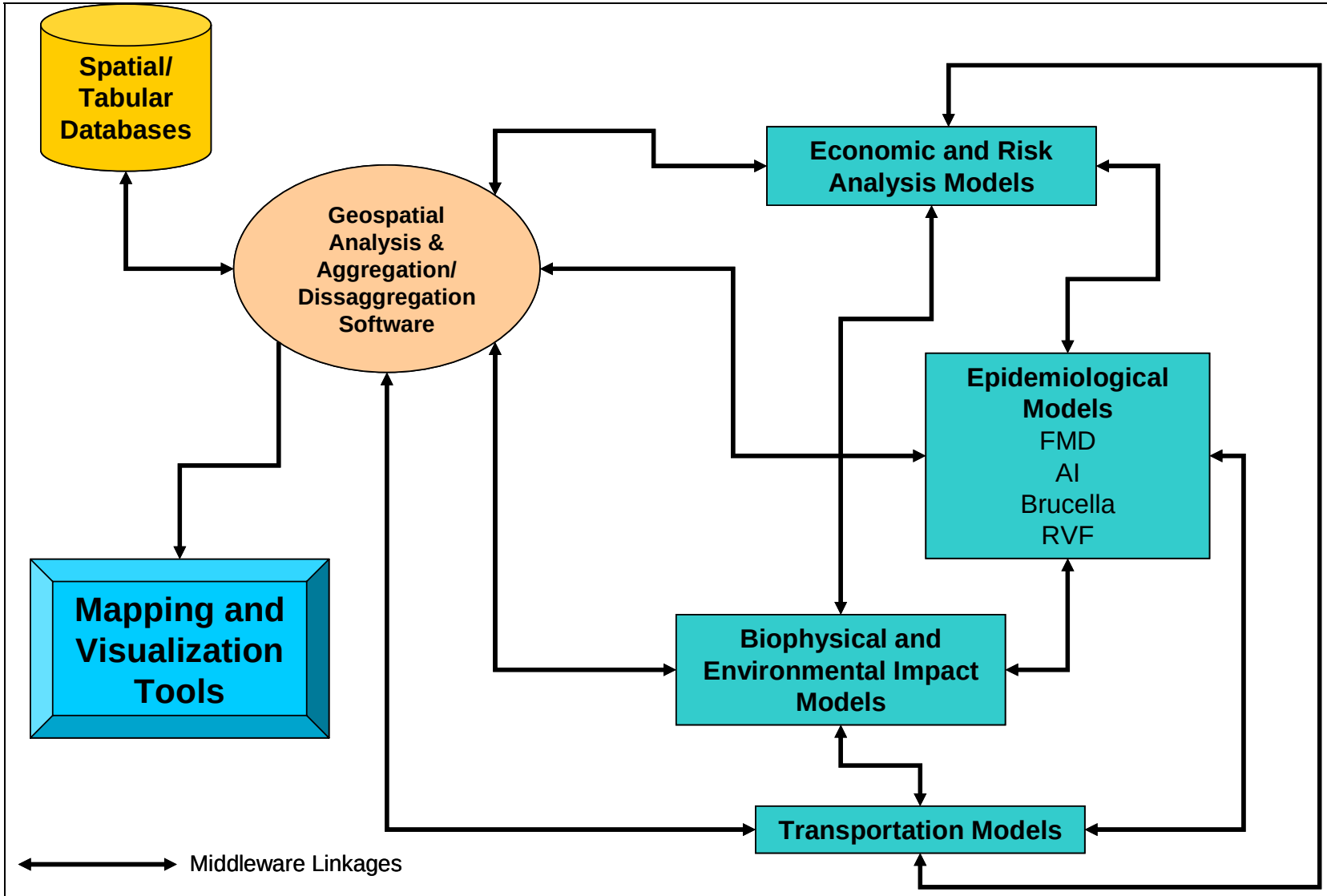

Figure 1. Conceptual framework for integrating the FAZD models using middleware linkages.

Technology Transition

Status of Funding

Funding is adequate for this task.