The COMPREHENSIVE ECONOMIC AND ENVIRONMENTAL OPTIMIZATION TOOL (CEEOT)

CEEOT is an integrated suite of economic and environmental models designed to simulate economic and environmental impacts of policy alternatives and individual practices or combinations of management practices. CEEOT was initially developed in 1995 at TIAER as part of a National Pilot Project (NPP) funded by the USEPA. Under the NPP initiative, CEEOT was applied to the dairy industry in the upper North Bosque River watershed (Osei et al., 2003a; Osei et al., 2000b; Pratt et al., 1997; Saleh et al., 2000) and the Lake Fork Reservoir watershed in eastern Texas (Osei et al., 2003b; McNitt et al., 1999). In subsequent years, the CEEOT modeling system was applied to the Upper Maquoketa River watershed in northeast Iowa—a region with dairy operations but also including beef cattle, swine, and mixed operations (Keith et al., 2000); and to the Duck Creek watershed—a central Texas region experiencing rapid growth of broiler operations (Keplinger and Abraham, 2002). In the upper North Bosque River watershed study, the CEEOT modeling system was also applied to several dairy management practices that were considered and subsequently included in the total maximum daily load (TMDL) implementation plan for the North Bosque River (Keplinger, 2003; TCEQ and TSSWCB, 2002).

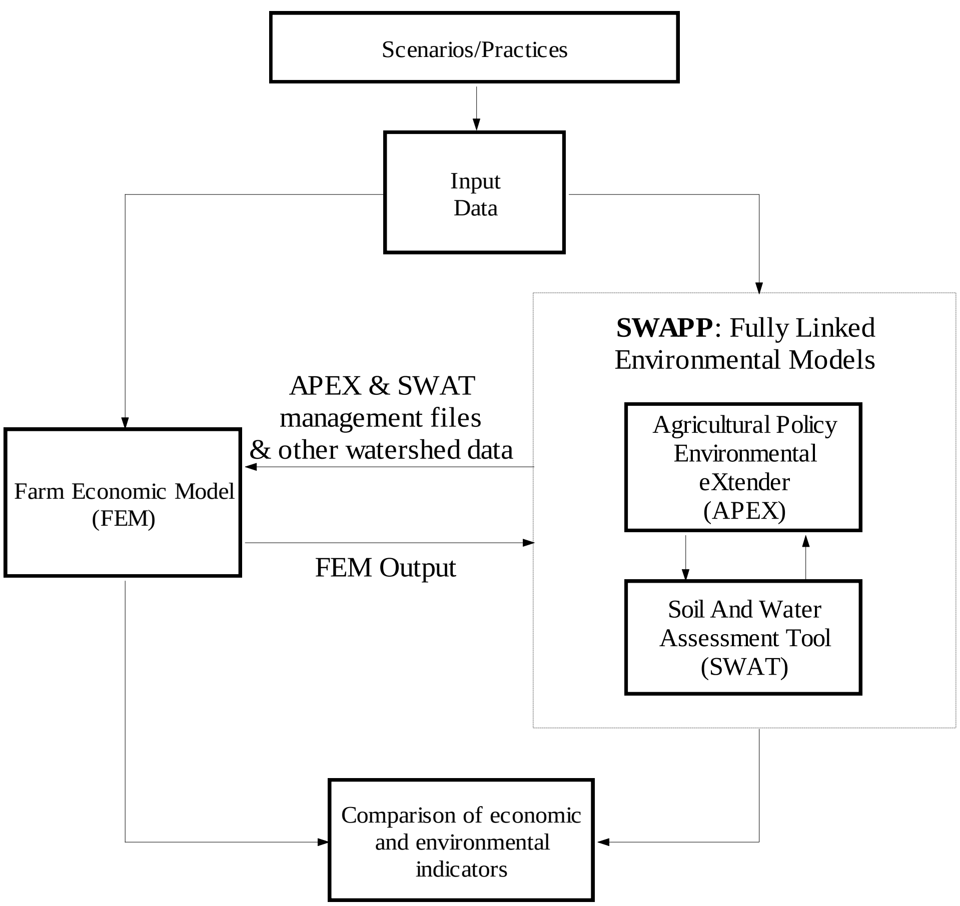

Figure: Schematic of the CEEOT modeling system.

CEEOT currently incorporates the following environmental and economic models: 1) the SWAPP program : the fully linked SWAT/APEX program with dynamic fertilizer management capabilities, and 2) the Farm-level Economic Model (FEM), a comprehensive farm-level economic model also developed at TIAER that combines simulation, optimization, and accounting features to estimate the economic impacts of scenarios on representative agricultural operations. A brief discussion of APEX, SWAT, and FEM is given here; more detailed description of CEEOT is provided in Osei et al. (2000a).

APEX (Williams et al., 2000) is a modified version of Environmental Policy Integrated Climate (EPIC; Williams, 1990), a field-level model that was developed in the early 1980s to assess the effects of management strategies on water quality. APEX extends the functionality of EPIC by allowing simultaneous simulation of multiple contiguous sub-areas (fields) for a wide range of soil, landscape, climate, crop rotation, and management practice combinations. It is designed for whole farm or small watershed analyses and can be used for applications such as filter strip impacts on nutrient losses from manure application fields that require the configuration of at least two sub-areas. The ability to simulate liquid waste applications from animal feeding operation waste storage ponds and waste treatment lagoons is a key component in the model for application to the North Bosque River watershed. Other components include weather, hydrology, soil temperature, erosion-sedimentation, nutrient and carbon cycling, tillage, dairy management practices, crop management and growth, pesticide and nutrient movement, and costs and returns of various management practices.

SWAT (Arnold et al., 1998) is a daily time step watershed model and was developed to overcome the limitations associated with nonpoint source modeling at the watershed scale by allowing continuous-time simulations with a high level of spatial detail through the division of a watershed or river basin into hundreds or thousands of grid cells or sub-watersheds. SWAT operates on a command structure for routing runoff and chemicals through a watershed. These commands allow the user to route flows through streams and reservoirs, combine flows, and input measured data (e.g., weather) and point source loading. The major components of SWAT include hydrology, weather, sedimentation, soil temperature, crop growth, nutrients, pesticides, and agricultural management. SWAT has a history of successful applications in addressing problems related to water, sediment, nutrients and pesticide, ranging from watershed scale to national scale, across the United Sates and in other countries (e.g., Arnold et al., 1999; Srinivasan et al., 1998; Saleh et al., 2000). SWAT, for instance, was utilized for a phosphorus TMDL analysis along the North Bosque River in Texas (Santhi et al., 2001a). At the national scale, the Hydrologic Modeling of the United States (HUMUS) project ran management scenarios to support the 1997 Resource Conservation Appraisal (RCA) using SWAT and a Geographic Information System (GIS) interface.

In recent work, Saleh (2004) developed a SWAT/APEX interface program that permits comprehensive simulation of management practices at the watershed level in a way that is not possible with either APEX or SWAT alone. For instance, SWAT is currently not very suitable for simulating double cropping systems. However, APEX is designed for such multi-cropping systems. Similarly, APEX by itself is designed for field-scale simulations and not for large watershed-level assessments, which are the strengths of SWAT. Earlier CEEOT applications entailed an integration of APEX and SWAT through manual file transfers. The SWAPP program automates these tasks and allows for efficient and flexible environmental simulation of a much broader array of scenarios. . Output from APEX, including edge-of-field sediment and agricultural nutrient losses, are routed in SWAT through the remaining land uses of the watershed (including urban land uses) to obtain total loadings at the output of the watershed of interest.

FEM (Osei et al., 2000a), the economic model used in CEEOT, is a whole farm annual time step model that simulates the economic impacts of various scenarios on agricultural operations (Osei et al., 2000a). FORTRAN routines within FEM are used to estimate costs and returns of a representative farm, based primarily on livestock and crop operations, ownership and characteristics of structures, facilities and equipment, financing terms, land areas and uses, livestock nutrition, and manure production and handling. Feed ration optimizations for livestock farms are handled within the General Algebraic Modeling System (GAMS; Brooke et al., 1992) submodule that is linked to special model routines for the transfer of relevant decision and exogenous variables. The model calculates fixed and variable costs of field operations using agricultural machinery management specifications tabulated in American Society of Agricultural Engineers (ASAE) Engineering Practice EP496.1 (ASAE 1995a) and ASAE Data D497.1 (ASAE 1995b). Economic life of machinery is also dynamically calculated based on annual hours of use and ASAE agricultural machinery management specifications.

CEEOT can be applied to evaluate a wide array of conservation practices or policies in any watershed in the U.S. where data are available. Additional information on CEEOT can be obtained in the following publications or by contacting Dr. Ali Saleh, TIAER: 254-968-9790.

Keith, G., S. Norvell, R. Jones, C. Maguire, E. Osei, A. Saleh, P. Gassman, and J. Rodecap. 2000. Livestock and The Environment: A National Pilot Project: CEEOT-LP Modeling for the Upper Maquoketa River Watershed, Iowa: Final Report. Report No. PR0003. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State University. Available at http://tiaer.tarleton.edu/pdf/PR0003.pdf.

Keplinger, K. and J. Abraham. 2002. Project Summary: CEEOT-LP Modeling for Duck Creek Watershed, Texas. Report No. PR0206. Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, TX.

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Srinivasan, R., J.G. Arnold, and C.A. Jones. 1998. Hydrologic Modeling of the United States with the Ssoil and Water Assessment Tool. International Journal of Water Resources Development. 1493): 315-325.

Williams, J.R., J.G. Arnold, and R. Srinivasan. 2000. The APEX model. BRC Report No. 00-06, Oct. 2000. 121 P.