

Project Narrative

Name of the Project: A Real-Time Drought assessment and forecasting system for Texas using GIS and remote sensing

Geographic Area of the Project: Texas

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Amount of Funding Requested: \$20,000

Project Need, Description and Expected Outcomes

Discuss the situation and need for the project, describe the proposed project and expected outcomes/benefits.

Drought is a normal, recurrent feature of climate that occurs in virtually every climatic zone around the world and brings about billions of dollars in loss annually for the farming community. According to US Federal Emergency Management Agency (FEMA) United States lose US\$6-8 billion annually on an average due to drought. Texas alone lost a staggering US\$5.8 billion during the 1998 drought. Hence a better tool for assessing and forecasting drought is essential for the farming community and the decision-makers. The primary objective of the proposed research is **"to develop a drought assessment system based on soil moisture deficit estimated using GIS, remote sensing and a comprehensive hydrologic model."**

Federal and State government agencies use drought indices to assess and respond to drought. A drought index integrates various hydrological and meteorological parameters like rainfall, evapotranspiration (ET), runoff and other water supply indicators into a single number and gives a comprehensive big picture for decision-making. The Palmer Drought Severity Index (PDSI), and Crop Moisture Index (CMI), are extensively used for water resources management and agricultural drought monitoring and forecasting. U.S. Department of Agriculture uses PDSI and CMI to determine the magnitude of drought and the time to grant emergency drought assistance for the farmers. PDSI and CMI are based on a simple lumped parameter water balance model that calculates precipitation deficit and ET deficit respectively. The model assumes that parameters like land-use/land-cover, soil properties are uniform over the entire climatic zone (7000 to 100,000 km²). However in reality, parameters like land-use/land-cover, soil properties vary widely. Several studies have highlighted this limitation of PDSI and CMI.

Due to the advancement in Geographical Information Systems (GIS), and GIS based distributed parameter hydrologic model we propose to develop a better drought assessment system. Integration of GIS and remote sensing techniques will assist in assessing moisture deficit at a resolution of 16km², as compared to one moisture deficit currently observed for the entire climatic zone (7000 to 100,000 km²). The increased resolution and spatial accuracy will give farming community, water managers and policy makers a better tool for assessing, forecasting and managing drought on a much finer scale. A comprehensive hydrologic model, Soil and Water Assessment Tool (SWAT) developed at Blackland Research Center, TX, will be used in this project to calculate soil moisture deficit using daily weather data and GIS. Using 60 years of weather data (1941-2000) in SWAT model simulations, long-term weekly soil moisture means will be established for Texas at a resolution of 4km × 4km. Soil moisture deficit can then be the deviation of the weekly mean soil moisture from the long-term weekly soil moisture

A cumulative probability distribution function of percentage soil moisture deficits can be built for each of the 52 weeks in a year using weekly soil moisture deficits obtained using sixty years of weather data. Based on the probability of occurrence of a given soil moisture deficit, five classes of drought severity will be defined. *The probability values defined under each class of drought are only for illustration purposes.* These probability values for each drought classes will be modified after analyzing the historical soil moisture data in different climatic regime of Texas, drought indices like PDSI and CMI, and crop yields for different parts of Texas reported by National Agricultural Statistical Service (NASS).

- *No drought* occurs when soil moisture deficits are close to zero or negative.
- *Mild drought* occurs when a soil moisture deficit of given magnitude is expected to occur 25-50 percent of

- *Moderate drought* occurs when a soil moisture deficit of given magnitude is expected to occur 16 - 25 percent of the time.
- *Severe drought* occurs when a soil moisture deficit of given magnitude is expected to occur 6-15 percent of the time.
- *Extreme drought* occurs when a soil moisture deficit of given magnitude is expected to occur less than 6 percent of the time.

A time series analysis will be conducted on the soil moisture deficit values obtained through this study to develop a model for forecasting soil moisture deficit. ARMA (Auto Regressive Moving Average) type model has been successful for modeling and forecasting hydrologic time series like, stream flow, rainfall and temperature. Since soil moisture deficit is also a hydrological time series, an ARMA type forecast model would be developed for forecasting soil moisture deficit. The time series data will be separated into two-halves. The first half of the data (1941-1970) will be used in the time series analysis for developing the drought forecast model. The second half of the data (1971-2000) will be used for drought forecast model validation. Based on the forecasted soil moisture deficit, and its probability of occurrence, one of the five drought classes will be assigned for drought forecast.

Once the drought assessment system has been established, the system will be operated on a daily basis by using the weather data obtained from NCDC weather stations. From the year 2000 onward, remotely sensed data from satellite (AVHRR - Advanced Very High Resolution Radiometer) and radar (NEXRAD - NEXt generation weather RADar) are collected and archived everyday at the Blackland Research Center, Temple, TX. ET information obtained from AVHRR and precipitation information from NEXRAD will be used in lieu of ET or precipitation obtained from ground based NCDC weather station data. Incorporating remotely sensed data with GIS will improve the accuracy and reliability of the drought assessment system. The expected outcomes of this research are:

1. Weekly soil moisture/soil moisture deficit information for Texas.
2. Weekly drought severity information of Texas.
3. Weekly/Monthly drought forecast information of Texas.

The drought assessment system, ET and soil moisture information developed in this research would be made available on the World Wide Web (WWW) and would serve as a better tool for farming community, water managers and policy makers for assessing, forecasting and managing drought.

The project will be conducted over a period of two years. During the first year, historical data will be analyzed and model runs will be conducted to develop the drought index. During the second year, time series will be developed for forecasting drought, the model will be validated with drought indices like (PDSI), and web interface will be developed to implement the drought assessment system.

Specific Issues Addressed

Relative to the needs of current water and/or conservation projects (listed in Section III, or others), what concern(s) is/are addressed by this project?

In 1997, the Texas Legislature passed Senate Bill 1, which is a comprehensive **water resources management** Act stresses the need for drought contingency and water management planning. The National Drought Policy Commission has recommended Congress to improve collaboration among scientists and managers to enhance effectiveness of observation networks, monitoring, prediction, information delivery, and applied research for drought. These concerns are addressed by the proposed project.

Collaboration

What agencies, groups, organizations, or additional TAES/TAEX disciplines are included in this project? List all collaborators and their function in the project.

The PI will work with Jeffrey Arnold of USDA-ARS at Temple, TX to develop SWAT model runs and extract soil moisture information from model inputs. The PI will also work with Texas Forest Service (TFS), Texas Water Development Board (TWDB), and Texas Natural Resources Conservation Commission (TNRCC) to evaluate the effectiveness of developed drought assessment system.

Signature of PI

Date

Signature of Unit Head

Date