**PROJECT TITLE: Adjusting Crop Water Demand to Protect Minnesota Groundwater**

1. **PROJECT STATEMENT**

***Agriculture is the most important export industry in Minnesota: half of the state’s land area is used for farming, and crop exports total $9.7 billion per year. But these crops need a lot of water.*** The state does not directly measure agricultural water usage, but we do know that ~1,200 new crop irrigation wells were installed in Minnesota from 2008–2012. Farmers pump more water out of these wells in dry years than in normal years. For example, in a dry year like 2013, more than twice as many farmers applied to pump >10,000 gal. of water per day. Irrigation volumes are especially high in central Minnesota because of its sandy, well-drained soils.

***In many places, farmers could use less water while maintaining crop yield—this would conserve groundwater.*** Many farmers are already taking steps to increase irrigation efficiency (e.g., planting cover crops and using smart irrigation technologies). However, they often have to rely on incomplete market knowledge and trial and error to make one very important decision—which cultivar to plant in the coming year. Each year, there are dozens of cultivars available for a given crop, and some need much more water than others. For example, some corn cultivars require 40% more water to produce the same yield under the same environment.

***We will make computer-generated maps to find places where farmers can save water without sacrificing crop yield.*** To do so, we will estimate the yield and water usage of 5 cultivars for each of 3 widely planted Minnesota crops (corn, soybeans, and wheat), taking into account different climate and soil conditions. Then, we will make maps to identify the most water-efficient cultivar in each area of the state. These maps will help farmers choose the best cultivar for their area, and will help water resource managers incentivize farmers to use these cultivars to reduce groundwater demand from irrigation.

***How are we going to do this?*** Crop water usage and yield depend on four factors: the physiology of the cultivars themselves, soil water supply, climate, and irrigation strategy. We will integrate these factors using:

1. **New knowledge about how each cultivar will respond** to different climate and soil conditions
2. **A cutting-edge crop and hydrological model combined with state-wide datasets** to determine cultivar-specific water usage and yield

Our results will be communicated to stakeholders—including commodity groups, extension agents, and DNR and MDA personnel—through online platforms, meetings, extension bulletins on relevant portals, and other means.

1. **PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1: *Assemble datasets on soils, crops, irrigation volumes, and climates* Budget: $ 75,386**

We will compile extensive datasets on soils, weather, crop yield, and irrigation volumes (from flood, sprinkler, and micro-irrigation) from the USDA, DNR, MDA, and statewide weather station networks. We will also compile—from existing literature and our own recent work—physiological data on Minnesota-adapted crop cultivars (corn, soybeans, and wheat). This information will be critical to the modeling efforts (Activity 2 and 3), by providing (i) a baseline for testing the ability of the model to reproduce observed crop yields, and (ii) input parameters for describing cultivar type-specific water use patterns under a wide range of environments.

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| **Outcomes** | **Completion Date** |
| 1. Assemble and process multiple datasets on soil, climate, irrigation by county, and crop physiology (for corn, soybean, and wheat).  | 05/2021 |

**Activity 2: *Develop models to predict cultivar water needs and potential yield* Budget: $ 81,248**

We will first develop crop water use models capturing the diversity of Minnesota-adapted crop cultivars. These models will integrate water use patterns for these cultivars, and how they will respond to a wide range of climates, soils, and irrigation practices. Importantly, these models will be developed specifically for each cultivar type, using a physiological typology that we have already developed. For example, we know that crop water use increases with atmospheric demand (e.g., when it’s hot and dry), soil water supply (from rainfall), and irrigation, but how much it increases will depend strongly on the traits particular to each cultivar, which can be used to define a spectrum of water use “types” (for example, from water-conserving to water-greedy). We will test the model results against actual crop yield data (from Activity 1) and refine the models’ abilities to accurately predict crop outcomes under a wide range of climate and irrigation scenarios.

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| **Outcomes** | **Completion Date** |
| 1. Develop and validate models for predicting crop water use and yield  | 12/2022 |

**Activity 3: *Use the models to make actionable maps of the most water-efficient cultivars* Budget: $ 82,577**

We will produce state-wide maps of crop water use and yield using the verified model from Activity 2, based on existing cultivar types, soils, and irrigation practices within each county (using data from Activity 1). Then, we will produce an additional set of maps that explore “what-if” scenarios in which crop water requirements and yield will be changed according to the deployment of different cultivar types and the application of different irrigation volumes, all under long-term projections of weather patterns across Minnesota. By comparing these two sets of maps, we will be able to analyze the tradeoffs between short-term yield gains and long-term environmental impact, and identify two features of interest: (i) the “optimal” cultivar type for each county that will result in the maximum yield with a given amount of irrigation water, and (ii) locations where there are large, unfulfilled potentials to reduce irrigation demand by deploying less water-intensive cultivars.

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| **Outcomes** | **Completion Date** |
| 1. Produce crop water usage and yield maps based on current and alternate scenarios  | 04/2023 |
| 2. Identify ideal locations for irrigation reduction and optimal cultivars for each county | 06/2023 |

1. **PROJECT PARTNERS** (receiving ENRTF funding unless otherwise noted)
* Dr. Xue Feng, Assistant Professor, UMN Dept. of Civil, Environmental, and Geo-Engineering
* Dr. Walid Sadok, Assistant Professor, UMN Dept. of Agronomy and Plant Genetics
* We will collaborate with USDA, DNR, and MDA (**not receiving ENRTF funds**) to acquire and interpret data
1. **LONG-TERM- IMPLEMENTATION AND FUNDING**

This is a new project that will provide foundational information for evaluating long-term crop water use across the state. Our maps will enable water resource managers to **(1) anticipate demands on groundwater aquifers from crop irrigation** (and appropriate permits accordingly),and **(2) better target water conservation efforts by identifying areas with large, unfulfilled potential for irrigation reduction**. Farmers can use the maps to choose the most water-conserving cultivar to maximize the profitability of their farms *and* the long-term sustainability of groundwater in their region. The maps will be shared publicly online and through meetings and presentations.

1. **TIME LINE REQUIREMENTS**

Three years of support (July 2020 – June 2023) are requested to collect, process, and analyze data (Activity 1), to construct computer models (Activity 2), to produce crop water use and yield maps based on current and alternate scenarios (Activity 3), and to ensure proper documentation and communication of results (Activity 3).