Understanding Drivers for the Dynamic Cropping System in Southwest Michigan

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INTRODUCTION

- Crop identification and delineating crop areas is one of the preliminary approach to understand cropping system dynamics, in which remote sensing (RS) plays a significant role.
- Southwest Michigan has diverse and evolving cropping systems.
- The working hypothesis of this study is that, evolving cropping systems alters the water-energy interactions in the landscape due to changes in landscape's roughness, which in turn will result in variable crop water requirements.

OBJECTIVES

The overall objective is to understand the drivers of the complex and evolving cropping systems in Southwest Michigan to improve irrigation efficiency and hence, profitability and sustainability. Specifically, four objectives were proposed to accomplish the task:

1. Mapping and analysis of annual Net primary productivity (NPP) evolution of Southwest Michigan from 2000 to 2015 using remote sensing
2. Estimation of county based field crop NPP using crop inventory data of NASS-USDA and comparison with remotely sensed NPP.
3. Estimation of ET_{actual} using satellite based image processing model, Surface Energy Balance Algorithms for Land (SEBAL).
4. Estimation of crop specific kc-curves for major crops (Corn-grain and Soybean) in Southwest Michigan using SEBAL output.

METHODOLGY

To accomplish the above objectives, we performed major tasks using ENVI (5.3) and ArcGIS(10.1) software tools at the Applied Agricultural System Modeling (AASM) lab in the Department of Plant, Soil and Microbial Sciences, Michigan State University.

TASK 1: Estimation of NPP using satellite based model: (Zhao et al., 2010 and Mu et al., 2011).

TASK 2: Estimation of crop NPP using NASS-USDA inventory: (NASS, 2016; Prince et al., 2001; West et al., 2010). The framework for task 1 and 2 can be visualized in figure 1.

TASK 3: Estimation of ET_{actual} using SEBAL model: (Bastiaanssen et al., 2005).

TASK 4: Estimation of crop specific kc-curves for major crops (Corn-grain and Soybean) in Southwest Michigan using SEBAL output: Framework of task 3 & 4 can be visualized through figure 2

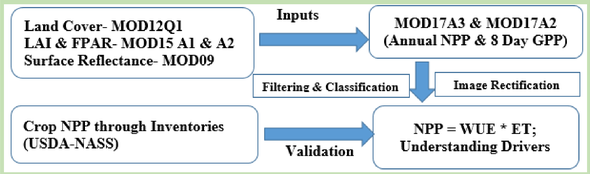

Figure 1. Framework for estimating and validating NPP to understand drivers of cropping system dynamics

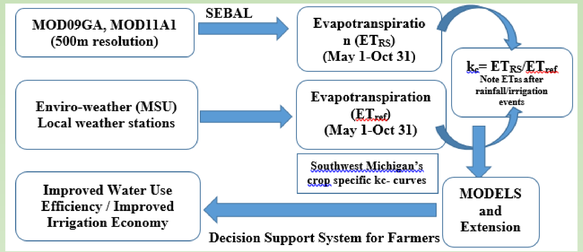

Figure 2. Framework for estimating ET_{actual} and improving Kc-curves for improving water use efficiency

RESULTS

TASK 1: Analysis have shown that from 2000 to 2015 most of the counties are loosing their total NPP (Figure 3). It is mainly due to urbanization (conversion of wetland to urban areas or deforestation). In further studies we are focused to delineate crop NPP through pixel based estimation from these satellite based model

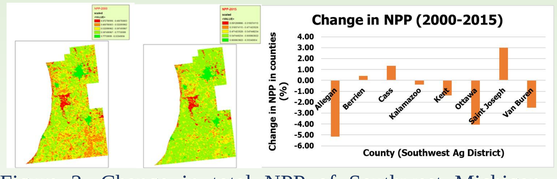

Figure 3. Change in total NPP of Southwest Michigan (2000-2015)

TASK 2: Crop NPP was estimated through inventory which is showing increase in yield for both corn and soybean although area for corn has increased but soybean harvested area has decreased (Figure 4.)

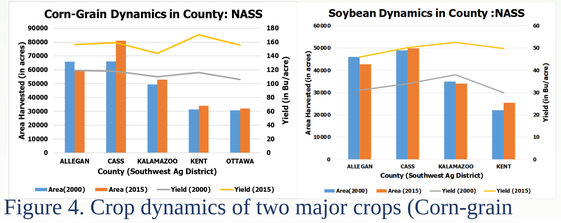

Figure 4. Crop dynamics of two major crops (Corn-grain and Soybean) (2000-2015)

Change analysis in figure 5 is depicting positive change in crop NPP in most of the counties except St. Joseph and Van Buren. St Joseph has major area going in pasture from field crop and Van Buren has missing data. Our results motivated us to do real time crop acreage delineation from satellite data to avoid the missing data issues.

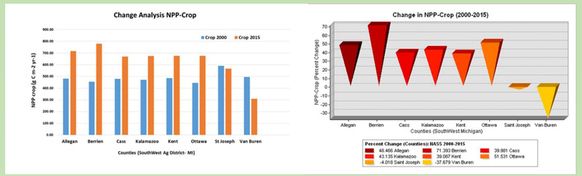

Figure 5. County estimates of change analysis of crop- NPP (2000-2015)

TASK 3: SEBAL estimated ET from most available data for cloud free dates and which is calibrated and validated with ground station for the year 2000 (figure 6) and 2015 (figure 7). We need to calibrate the SEBAL further for robust result.

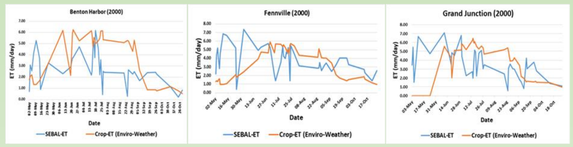

Figure 6 . Comparison of SEBAL- ET and Crop-ET for 3 Enviro-Weather Station (2000)

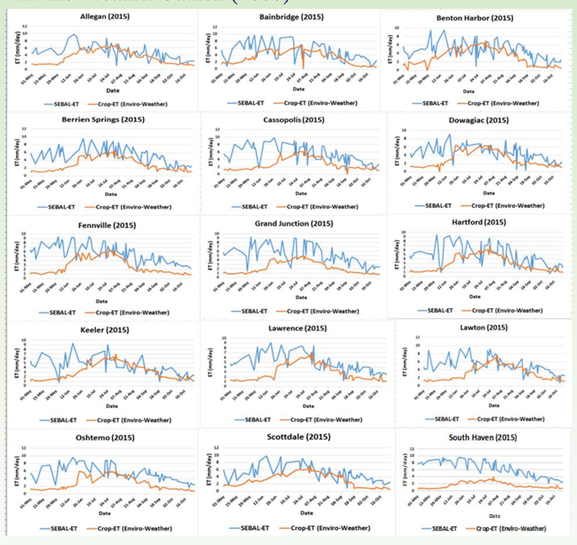

Figure 7 . Preliminary results and comparison of SEBAL-ET and Crop-ET for 15 Enviro-Weather Station (2015)

TASK 4: Crop specific kc-curves were estimated for major crops (Corn-grain and Soybean) using SEBAL output and ET ref from Enviro-Weather Station. Two assumptions were:- a) Conditions were assumed optimum (non-stress) and (b.) Planting dates were assumed uniform as May 1, which practically must vary from farm to farm and county to county. In our further studies we will, readjust Kc-curves with real time soil moisture condition to get robust Kc-curve

Estimated kc-through remote sensing for corn-grain and soybean for the year 2000 and 2015 is shown in figure 8.

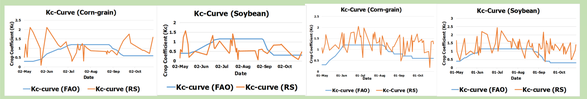

Figure 8. Kc-Curve (FAO and RS) for Corn –grain and soybean for cropping season of 2000 and 2015 (preliminary)

CONCLUSIONS

- Studying evolution pattern of NPP of southwest Michigan's cropping system gives a understanding of vegetation (crop) pattern is changing.
- RS plays vital role in identifying and fulfilling missing information in crop inventories.
- Estimation of ET through RS gives estimation of revised Kc-curves for specific crops which need to adjust for optimum condition
- To achieve high irrigation efficiency in a cropping season, it is important to optimize water use through informed technological management.
- This project will have a significant impact to growers in Southwest Michigan for optimizing their water use efficiency in crops.

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