Effective Rainfall, Water Yield, and Groundwater Recharge Under Different Crops Across the Brazos Watershed, TX

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Abstract

Increase demand for water resources across the Brazos watershed, Texas requires an evaluation of the potential impact of some of the major crops grown on this watershed. This study evaluated the potential effect of four major row crops (corn, sorghum, cotton and wheat) on the effective rainfall, the portion of gross rainfall that infiltrates into the crop rootzone, water yield, and groundwater recharge. Five locations in five different counties across the Brazos watershed (upper, middle and lower parts) were selected. Historical daily weather data [rainfall and potential evapotranspiration (ET_o)], soil physical properties, and crop water parameters were used as input for the Irrigation Management System (IManSys) model to calculate daily water budget components. From the upper to the lower parts of the watershed, rainfall increased by as much as 175% while ET_o decreased by 30%. The water yield increased with increase in rainfall across the watershed irrespective of the crop. The magnitude of effective rainfall for wheat at different locations was comparatively higher than that of the other crops. The water requirement for sorghum was comparatively lower than other crops. Groundwater recharge, in terms of percentage of gross rainfall, was the highest for wheat at all locations except at Lubbock. Cotton, Corn, and Sorghum had similar recharge rates at all locations. Water yield increased with increase in rainfall across the watershed irrespective of the crop. Further analyses are needed for more conclusive conclusions and recommendations.

Introduction

Increase demand for water resources across the Brazos watershed (**Fig. 1**), Texas requires an evaluation of the impact of some of the major crops grown on this watershed. The major crops grown in this watershed are cotton, winter wheat, corn, sorghum etc (**Fig. 2**). The changes in acreage covered by these crops are shown in **Fig. 3**. Cotton has the highest acreage while winter wheat has the lowest acreage in 2011 during last six years (2008 – 2013).

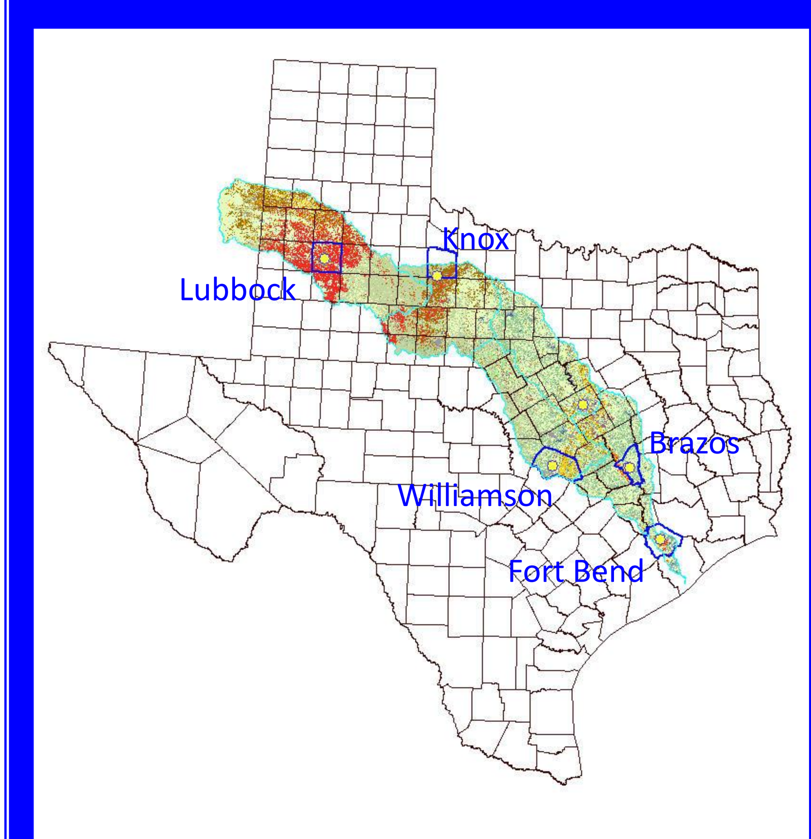


Fig. 1: Location of Brazos and selected county

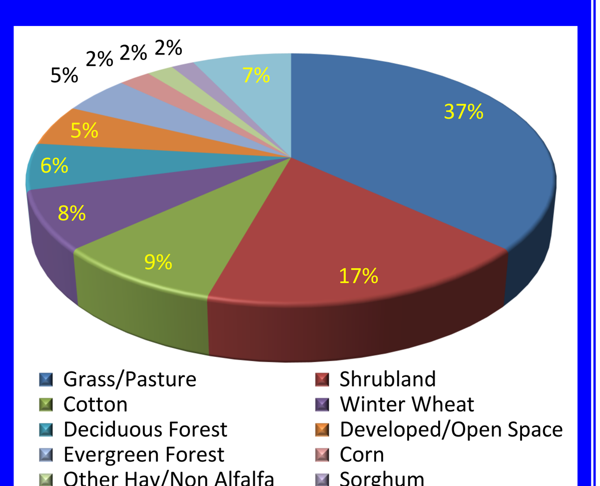


Fig. 2: Major land cover of Brazos river basin (2013)

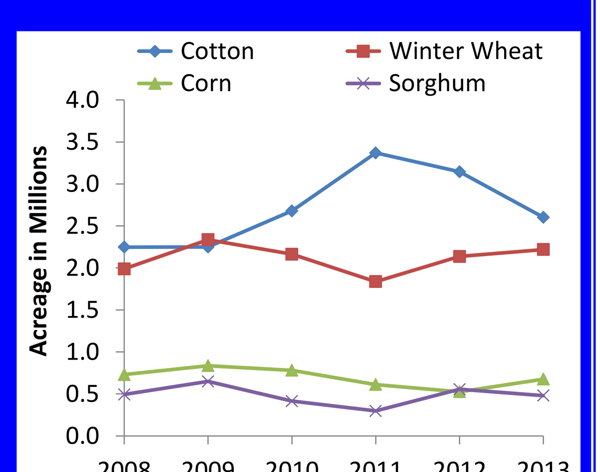


Fig. 3: Acreage of major croplands (2008 – 2013)

Objectives

The main objective of this study is to evaluate the potential effect of four major row crops on the effective rainfall, groundwater recharge rates, and runoff/water yield across the Brazos watershed using a IManSys and site specific historical data.

Methodology

Data:

Climate data (rainfall and potential evapotranspiration) at five stations of Texas ET Network and soil data derived from Soil Survey Geographic Database (SSURGO) were used in this study. Planting date, harvesting date and growing season of each crop were selected based on the geographic location of the area as detailed in Borrelli et al. (1998).

Table 1: Growing season of selected crops (Based on Borrelli et al., 1998)

Lubbock

Crops	Planting date	Harvesting date	Growing season (days)
Corn	15-Apr	18-Sep	157
Sorghum	29-May	25-Oct	150
Cotton	20-May	21-Oct	155
Wheat	27-Sep	25-Jun	272

Knox

Crops	Planting date	Harvesting date	Growing season (days)
Corn	22-Apr	09-Sep	141
Sorghum	02-Jun	30-Oct	151
Cotton	01-Jun	07-Nov	160
Wheat	02-Oct	19-Jun	261

Williamson

Crops	Planting date	Harvesting date	Growing season (days)
Corn	25-Mar	09-Aug	138
Sorghum	04-Apr	09-Aug	128
Cotton	24-Apr	21-Sep	151
Wheat	20-Oct	14-Jun	238

Brazos

Crops	Planting date	Harvesting date	Growing season (days)
Corn	07-Apr	07-Aug	123
Sorghum	09-Apr	24-Jul	107
Cotton	20-Apr	17-Sep	151
Wheat	22-Oct	22-Jun	244

Irrigation Management System (IManSys) model:

IManSys model (Fares and Fares, 2012) calculates daily irrigation requirements (IRRs) and other water budget components (runoff, drainage, canopy interception, and effective rainfall) using daily historical climate data (rain and evapotranspiration), and site and crop specific information (e.g., plant growth parameters, soil properties, irrigation system).

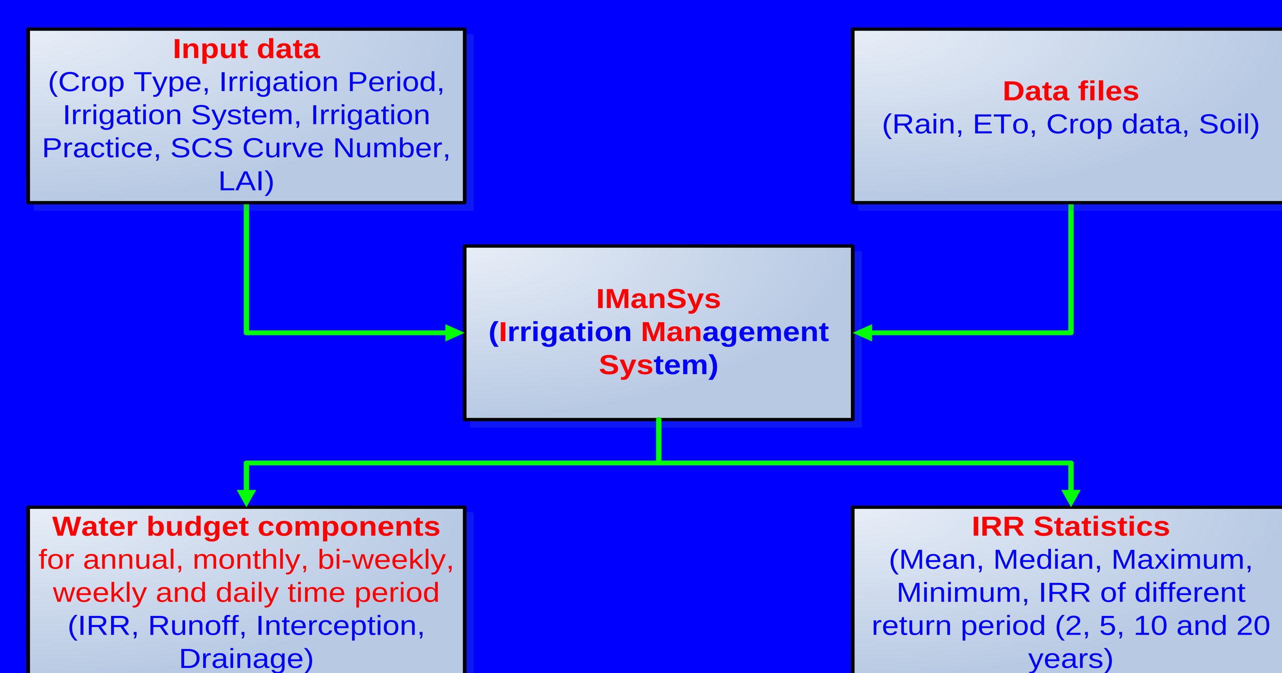


Fig. 4: Schematic representation of IManSys

Results and Discussions

Five locations in five different counties across the Brazos river basin (upper, middle and lower parts) were selected. Historical daily climate data (rainfall and ET_o), soil physical properties, and crop water parameters were used as input for the IManSys model.

Rainfall and potential evapotranspiration:

From the upper to the lower parts of the watershed rainfall increase by as much as 175% while ET_o decrease by 30% (Fig. 5).

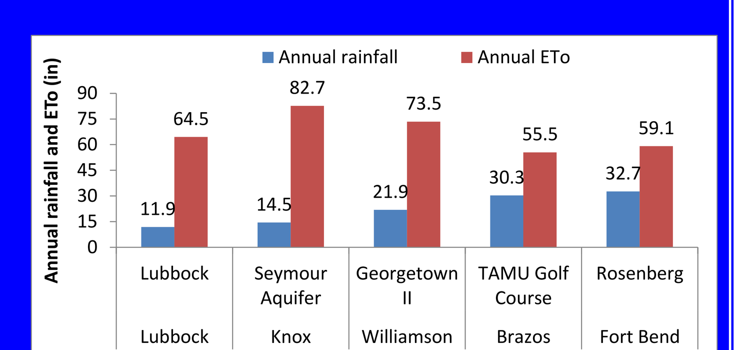


Fig. 5: Annual total rainfall and ET_o at different sites based on data of Texas ET Networks (2009 – 2013)

Effective rainfall:

The variation in magnitude of effective rainfall, the portion of gross rainfall that infiltrates into the crop rootzone across the growing season, for different crops was smaller at Lubbock where total annual rainfall was lowest among five locations. The variation was higher at Brazos and Fort Bend where total annual rainfalls were comparatively higher.

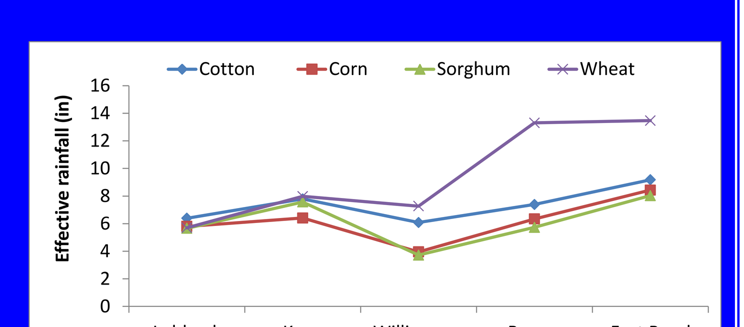


Fig. 6: Effective rainfall

Net irrigation requirement:

The water requirement for sorghum was comparatively lower than other crops. Water requirement for cotton was higher than other three crops at Williamson, Brazos and Fort Bend whereas water requirement for wheat was higher than other three crops at Lubbock and Knox.

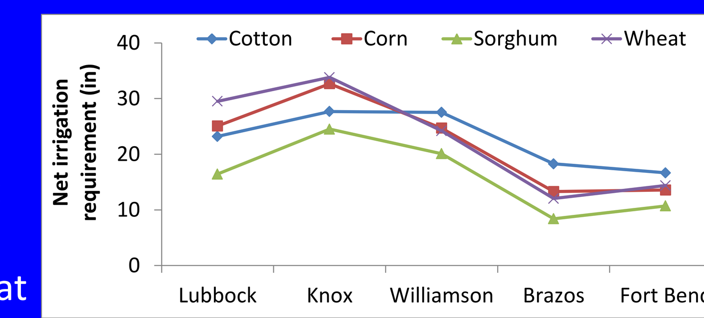


Fig. 7: Net irrigation requirement

Water yield:

Water yield increased with increase in rainfall across the river basin irrespective of the crop.

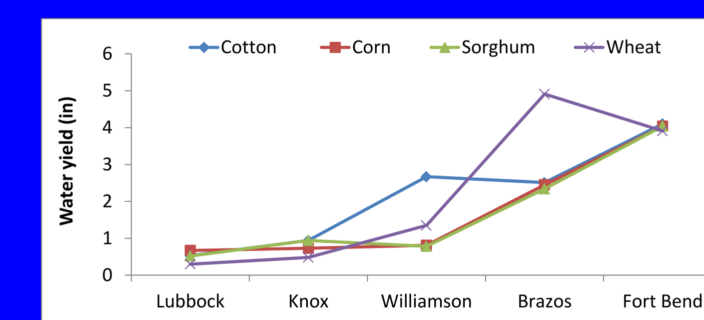


Fig. 8: Water yield

Groundwater recharge:

Groundwater recharge, in terms of percentage of gross rainfall, was the highest for wheat at all locations except at Lubbock. Cotton, Corn and Sorghum had similar recharge rates at all locations.

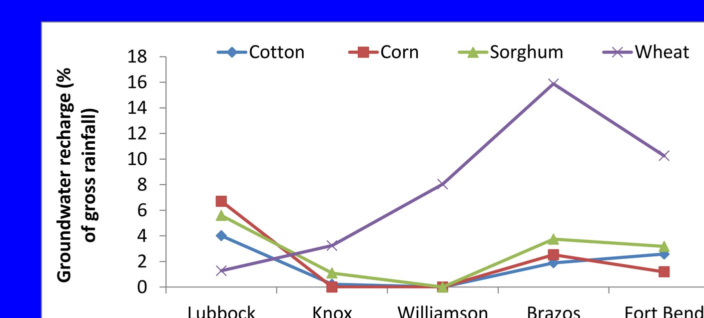


Fig. 9: Groundwater recharge

Crop evapotranspiration:

Crop evapotranspiration of Sorghum was lower than other crops irrespective of the locations.

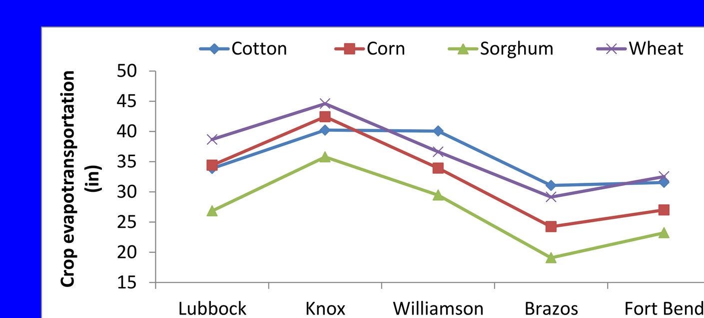
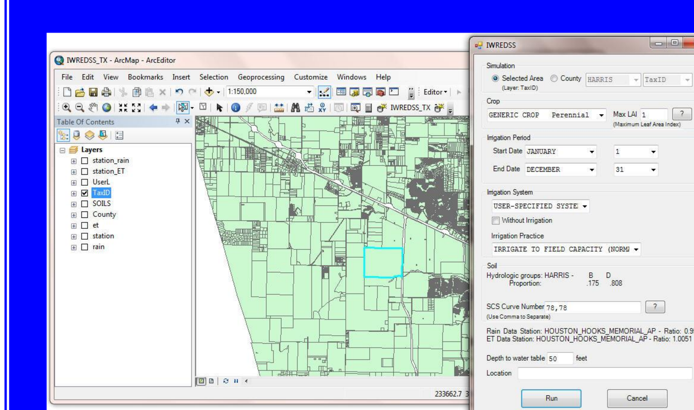
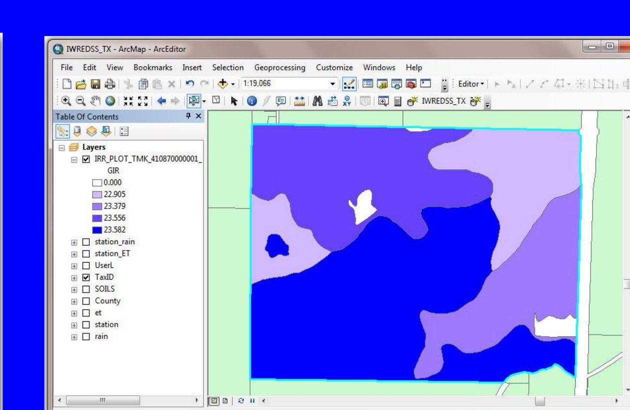


Fig. 10: Crop evapotranspiration

Future Work

Further study will incorporate all other crops and long term climate data of all available stations within the basin. Further study will use GIS based Irrigation Water Requirement Estimation Decision Support System - Texas (IWREDSS_TX) model which is currently under development at Prairie View A&M University, Texas.





Conclusions

IManSys proves to be a very useful tool to study relationship between different components of water budget and agricultural crops under different conditions. The result shows water requirement for sorghum is comparatively lower than other crops mainly due to its lower crop evapotranspiration. Groundwater recharge, in terms of percentage of gross rainfall, is the highest for wheat at all locations except at Lubbock.

Acknowledgements

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References

- Borrelli, J., Fedler, C.B., and Gregory, J.M. (1998): Mean Crop Consumptive Use and Free-Water Evaporation for Texas. Dept. of Civ. Eng, Texas Tech Univ., 271 pp.
- Fares, A. and Fares, S. (2012): Irrigation Management System, IManSys, a User-Friendly Computer Based Water Management Software Package. In: Proceedings of the Irrigation Show and Education Conference, Orlando FL, Nov. 2 – 6, 2012.