SIMULATION ***OUTSIDE*** OF THE BOX

Modeling the Potential of Water Harvesting Technology Using DSSAT

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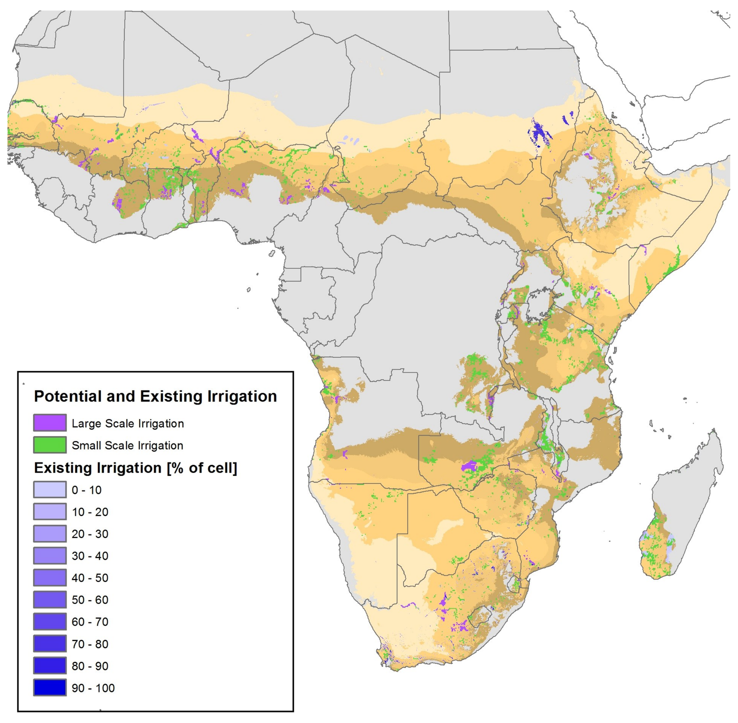
INTRODUCTION

WATER MANAGEMENT CHALLENGE IN RAINFED FARMING IN AFRICA

Rainfall variability is one of the largest rainfed crop production constraints in Africa, where only 5% of cropping land is currently irrigated. Potentially profitable areas for large- and small-scale irrigation are very limited.



1 EXISTING IRRIGATED AREA AND POTENTIAL FOR IRRIGATION EXPANSION IN AFRICAN DRYLANDS
Source: You et al., 2010 "What is the irrigation potential for Africa?" http://goo.gl/g3ieBY

RUNOFF HARVESTING

Harvesting runoff of rainwater in-situ or a small water reservoir/ pond next to the field and use for supplementary irrigation when it's needed. It's not a new technology. Various types of water harvesting methods, which channel water to crop fields from macro– or micro-catchment systems, have been practiced for centuries in the Middle East, Africa, Mexico, South Asia, and China. Its adoption is widespread, but the level of adoption remain low.

2 RAINFALL HARVESTING POND IN A RICE FIELD BENIN
Source: Authors (Benin, July 2012)

RESEARCH QUESTION

What will be the potential of adopting the ex-situ runoff rainfall harvesting technology in rainfed maize growing areas in semi-arid agro-ecological zone in Africa?

OBJECTIVES

1. Implement a modeling framework of simulating (ex-situ) harvesting of runoff rainfall water technology using DSSAT.
2. Develop a spatially-explicit modeling framework for simulating the WH technology in the semi-arid areas in Africa.
3. Analyze the potential of widely-adopting the WH technology in the region.

BUT… HOW?

DSSAT doesn't come with an option to simulate water harvesting technology!

USE DSSAT AS A FUNCTION TO ESTIMATE THE STATUS OF CROPPING SYSTEM IN THE MODELING FRAMEWORK

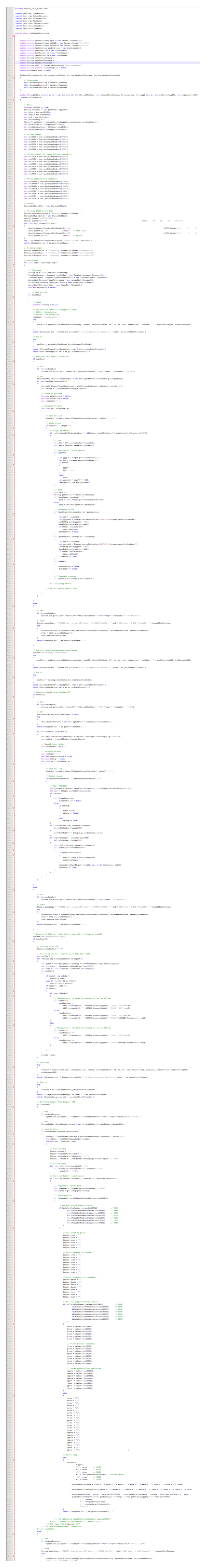
DSSAT simulates the complete water and nutrient balances in the system already. This enables advances users to test a new set of management practices outside-of-the-tool without changing the software itself.

METHODS

IMPLEMENTATION: WATER HARVESTING

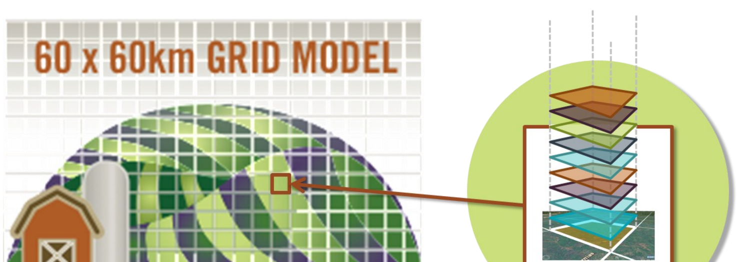
A two-stage simulation approach was implemented with an external program coded in Java (No DSSAT codes were harmed in the process).

1. **The simulation is first run *without* water harvesting.** From the simulation output, the phenology of each season (planting, flowering, and maturity dates) as well as runoff from the field are recorded. Assuming some water storage potential that captures runoff, the seasonal simulation output was further analyzed to determine when supplementary irrigation would be most needed (e.g., soon after germination and before flowering, when accumulated runoff was greater than 25 mm), and how much of the harvested water would be available from the storage device (e.g., 80 % of runoff was available to the field as supplementary irrigation).
2. **The simulation was then run again *with* the supplementary irrigation applied** when there are the needs of supplementary irrigation and available runoff water accumulated in the assumed water storage.



3 SOURCE CODE FOR APPLYING WATER HARVEST AT EACH SITE
Source: Authors

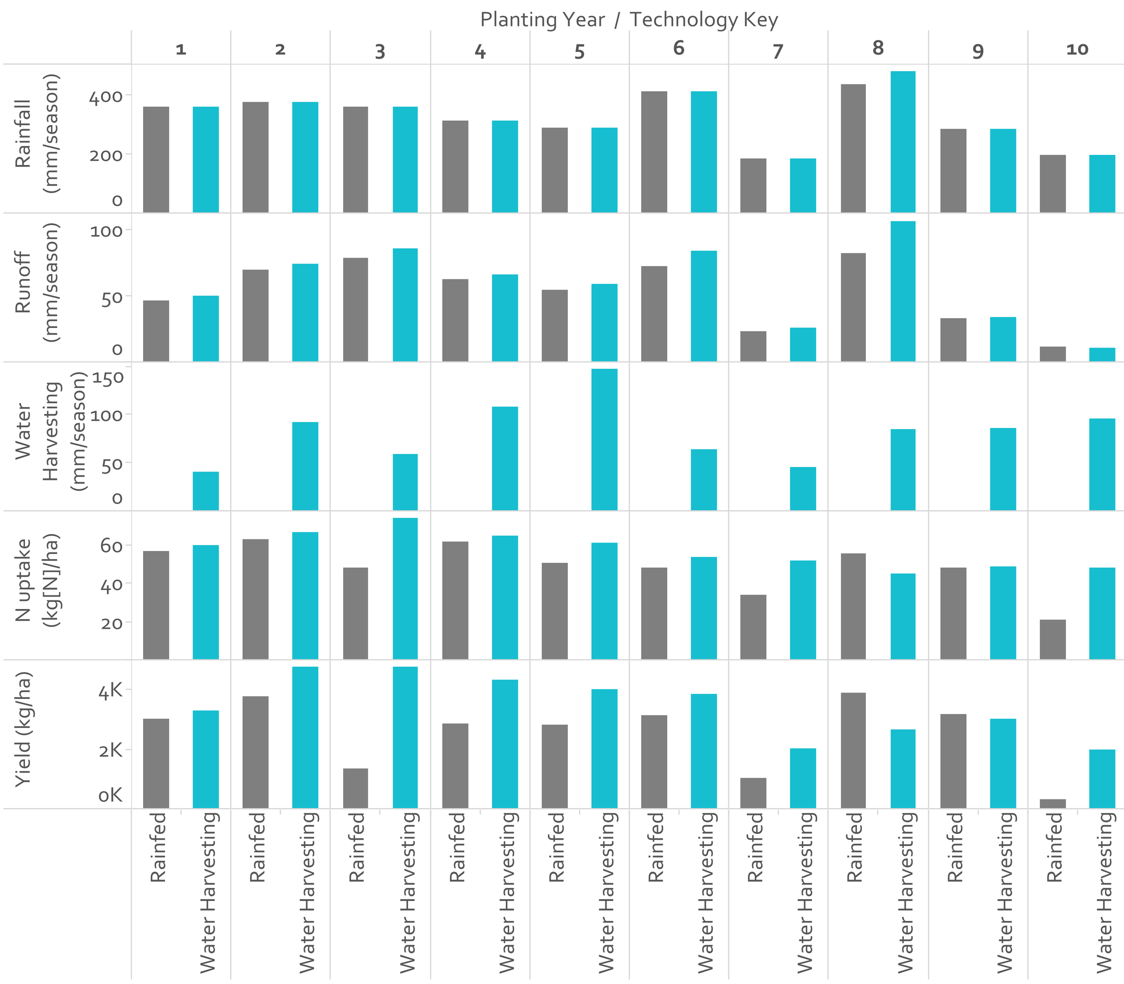
IMPLEMENTATION: TOUCAN GRID-BASED MODELING FRAMEWORK



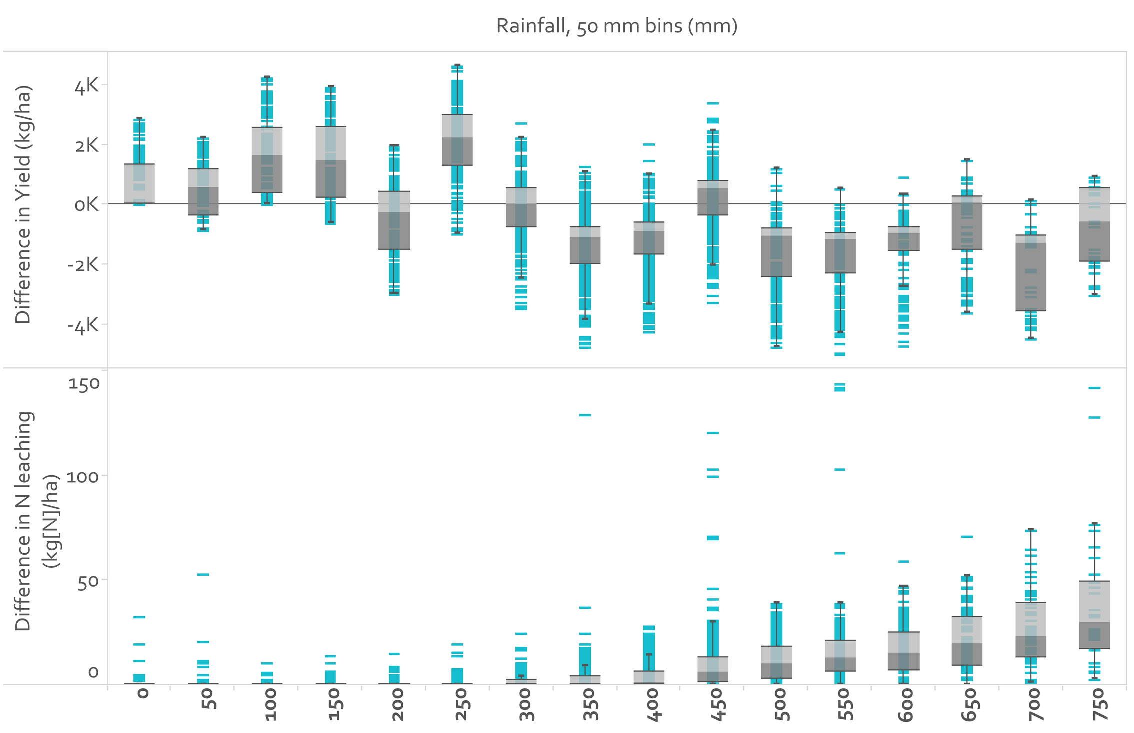
HarvestChoice's grid-based crop modeling framework, *Toucan*, was used in the study at 0.5 -degree spatial resolution (1,333 cells). Study area covered 11 countries in Sub-Saharan Africa. For each grid cell, soil profile and daily weather data for 10-year period were prepared. Soil data was based on the HC27 Generic Soil Profile Database http://hdl.handle.net/1902.1/20299. Planting month was based on the CCAFS Generic Rainfed Planting Month data layer. A sequential simulation was setup to run continuous maize cultivation for the 21-year period. Daily weather data was retried from AgMIP Climate Forcing Datasets http://data.giss.nasa.gov/impacts/agmipcf. Other technical details on the modeling setup can be found at Rosegrant et al., 2014*.

RESULTS

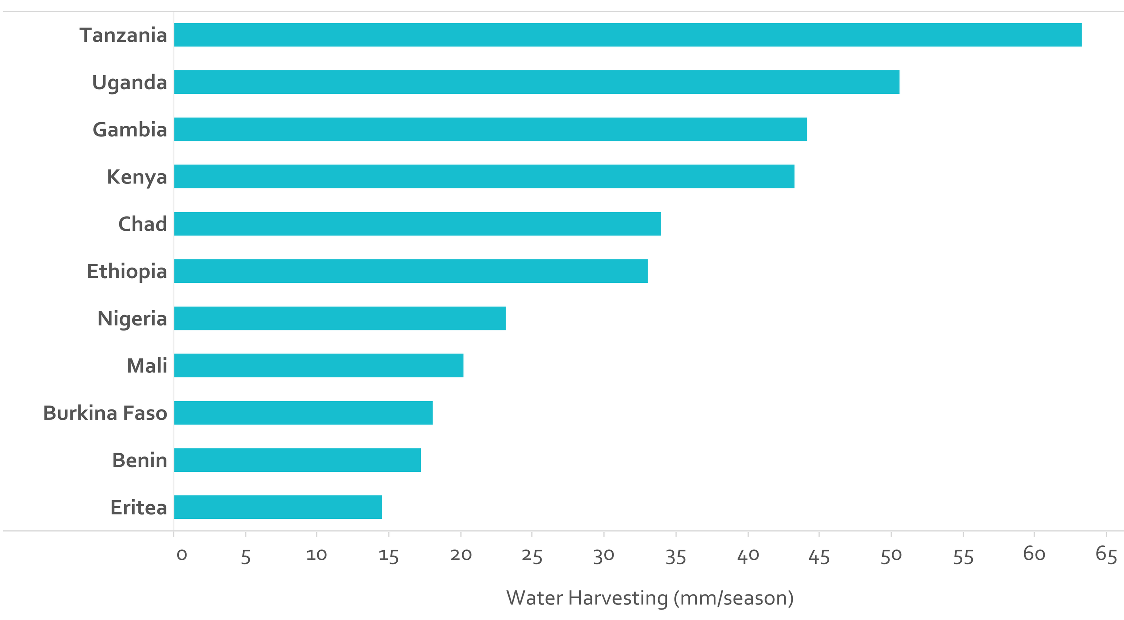
At each grid cell (site), simulation was run for 10-year period sequentially. Figure 4 shows the results at a site in Tanzania, showing the seasonal



4 SITE-SPECIFIC RESULTS IN TANZANIA (CELL ID: 134346) COMPARING THE RAINFED CASE WITH AND WITHOUT WATER HARVESTING IMPLEMENTATION Source: Authors



5 DIFFERENCES IN SIMULATED YIELD AND N LEACHING PER THE RAINFALL BIN OF 50 MM WITH AND WITHOUT WATER HARVESTING IMPLEMENTATION Source: Authors

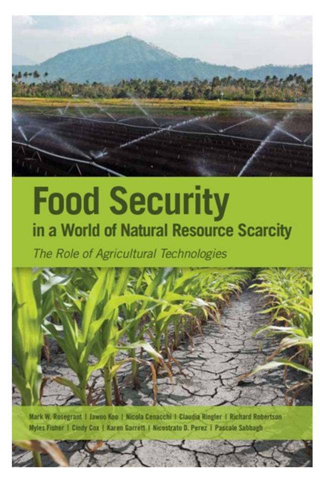


6 COUNTRY-LEVEL RANKING OF THE POTENTIAL OF WATER HARVESTING AVERAGED ACROSS EACH COUNTRY USING HARVEST AREA AS WEIGHT Source: Authors

changes in the water and nitrogen balance components, water harvest amount used for the supplementary irrigation, and yield differences. However, the positive yield impact was not always apparent. Especially in the sites with seasonal rainfall above about 350 mm, yields with water harvesting were often less than without water harvesting. This pattern was closely linked with the increased N leaching caused by additional application of supplementary irrigation.

CONCLUSION

This technique was used as one of the key technologies to address food security under scarce natural resources in a recently published integrated assessment study, estimating the regionally aggregated potential of increasing maize yield of up to 10% under future climate scenarios in 2050. This approach can allow researchers to study the potential of new technologies that are not yet implemented in the model and stimulate creative use of crop systems modeling tools beyond what they offer out of the box.



* Approach described in this poster was developed and used in an IFPRI-published study published in 2014, "Food Security in a World of Natural Resource Scarcity: The Role of Agricultural Technologies" in which authors assessed the potential impacts of agricultural technologies on farm productivity, prices, hunger, and trade flows were site-specifically estimated using DSSAT biophysical model linked with IMPACT global partial equilibrium agriculture sector model. | Citation of the full study: Rosegrant, M.W., **J. Koo**, N. Cenacchi, C. Ringler, R. Robertson, M. Fisher, **C. Cox**, K. Garrett, N.D. Perez, and P. Sabbagh. 2014. Food security in a world of natural resource scarcity: The role of agricultural technologies. IFPRI, Washington, D.C. | The publication is available at http://www.ifpri.org/publication/food-security-world-natural-resource-scarcity.

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