INTEGRATED DECISION SUPPORT SYSTEM FOR EVALUATING SMALL SCALE IRRIGATION TECHNOLOGIES IN DIMBASINA WATERSHED, GHANA

Abeyou W. Worqlul¹, Yihun T. Dile², Jean-Claude Bizimana³, Jaehak Jeong¹, Petra Schmitter⁴, Thomas Gerik¹, R. Srinivasan², James W. Richardson³ and, Neville Clark²

¹ Texas AgriLife Research, Temple, Texas, USA
²Texas A&M University, College Station, Texas, USA
³Department of Agricultural Economics, Texas A&M University, College Station, Texas, USA
Project Components

- Farm family surveys of factors affecting adoption of small-scale irrigation,
- Demand-driven research demonstrations of small-scale irrigation interventions,
- Use of Integrated Decision Support System (APEX, SWAT, FARMSIM) to simulate production, environmental, economic, and nutritional impacts of small-scale irrigation, and
- Capacity building (IDSS training, graduate student support, on-farm farmers training, etc)
Feed the Future Innovation Lab for Small Scale Irrigation Integrated Decision Support System (IDSS) sites in Africa.
Integrated Decision Support System

- SWAT: Watershed Impacts
- APEX: Crop and Forage Growth
- FARMSIM: Economic and Nutritional Impacts
- IDSS: Production, Environment Economics, and Nutrition
- PHYGROW: Pasture Conditions
- NUTBAL: Animal Performance
- SWAT calibrated parameters for a nearby watershed **White Volta** basin transferred to Dimbasina SWAT site;
- APEX was setup for SWAT subarea;
- APEX is calibrated for Corn and Sorghum and the calibrated parameters for these crops are transferred back to SWAT
- Calibrated crop yields are entered in FARMSIM for economic analyses
SWAT model calibration was done using streamflow at the Pwalugu river gauging station in White Volta.

- NSE = 0.77
- PBIAS = 25%

Result: Stream flow
Calibration SWAT/APEX – Runoff

Nash-Sutcliff Efficiency (NSE) = 0.88
R-square value of 0.94
Comparison of APEX vs. FAOSTAT maize and sorghum yield from 1983 to 2013
Crops were grown on suitable land based on their distribution for the baseline;

Irrigation water requirement > recharge
APEX Scenarios

- **Scenario 1**: multiple cropping of fertilized maize with vegetables (fertilized maize + tomato, fertilized maize + pepper, fertilized maize + fodder);
- **Scenario 2**: multiple cropping of fertilized sorghum + tomato, sorghum + pepper, sorghum + fodder;
FARMSIM Scenarios

Scenario description
- Baseline scenario: low fertilizer + no irrigation
- Alternative scenarios (5):
  Irrigation of tomatoes, red pepper and fodder (vetch & oats) + recommended fertilizers + dual cropping of veg./fodder with sorghum or maize + use pulley, diesel and solar pump for irrigation

Water lifting technologies:
- Pulley/bucket: 8 liters/min
- Motor pump operated by diesel: 120 liters/min
- Motor pump operated by solar power: 40 liters/min

Total potential irrigable land: 450 ha
Maize yields when continuously cropped and when grown as a multiple crop with pepper, fodder, and tomato (from 1983 to 2013).

![MAIZE YIELD Graph](image)

- **Temperature stress**
- **Water stress**
- **Nitrogen stress**

Yield (t/ha) vs. Number of stress days (days/year)
VEGETABLE CROP YIELD

- **Temperature stress**
- **Water stress**
- **Nitrogen stress**

**Yield (t/ha)**

**Number of stress days (days/year)**

- **Pepper**
  - + **Pepper + maize**
  - + **Pepper + sorghum**

- **Tomato**
  - + **Tomato + maize**
  - + **Tomato + sorghum**

- **Fodder**
  - + **Fodder + maize**
  - + **Fodder + sorghum**
Dimbasinia community

- Analysis of alternative irrigation technology in Dimbasinia community given the following:
  - Agricultural land: 2,064 ha (60% suitable for irrigation slope less than 6%)
  - Fodder (slope 6 to 8%), other 50% paper and tomato
  - Dryland maize and sorghum (grown in wet season) and irrigated tomatoes and red pepper (grown in dry season)
  - Number of cows: 771
  - Number ewes and nannies: 835 and 1975
  - Number of families: 374

- Irrigation costs:
  - Equipment costs: 2260 to 3000 GH₵/family (Diesel and solar pump + accessories)
    - Note: a pulley/bucket system: 235 GH₵
  - Operational costs (fuel, maintenance, rental): 235 - 290 GH₵/ha
Net Present Value (NPV)

StopLight Chart for Probabilities of NPV Less Than 16,000 and Greater Than 44,000 GH₵

Legend

Baseline: No irrigation
Alt.1: Pulley-SV
Alt.2: Rope-WS
Alt.3: Diesel_PR-SV
Alt.4: Diesel_PO-SV
Alt.5: Solar_P-SV
Nutrition Results

- Increase in quantity available per day and per adult equiv. under alt. scenarios for calories, proteins and fat
  - Improvement from the baseline (High level)

- Levels of Ca, Iron and Vitamin A increased also from Baseline to Alternative scenario:
  - Improvement from baseline (adequate level)
Conclusions

- There is large water resources potential in the Dimbasinia watershed. However, the average annual irrigation water requirement for cultivating pepper/tomato and fodder was more than the average annual shallow groundwater recharge.
- Addition of 50 kg/ha of urea and 50 kg/ha of DAP doubled simulated maize and sorghum yields.
- Additional fertilizer, multiple cropping and irrigation performed better than baseline scenario.
- Solar pump was the preferred water lifting technology – less maintenance cost and environmentally friendly.