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Potential for upscaling small scale irrigation (IDSS) – constraints and opportunities

Yihun Dile, Texas A&M University

ILSSI Stakeholder Consultation - Ghana, Coconut Grove Hotel Accra - 14th May 2018

Photo: Nana Kofi Acquah

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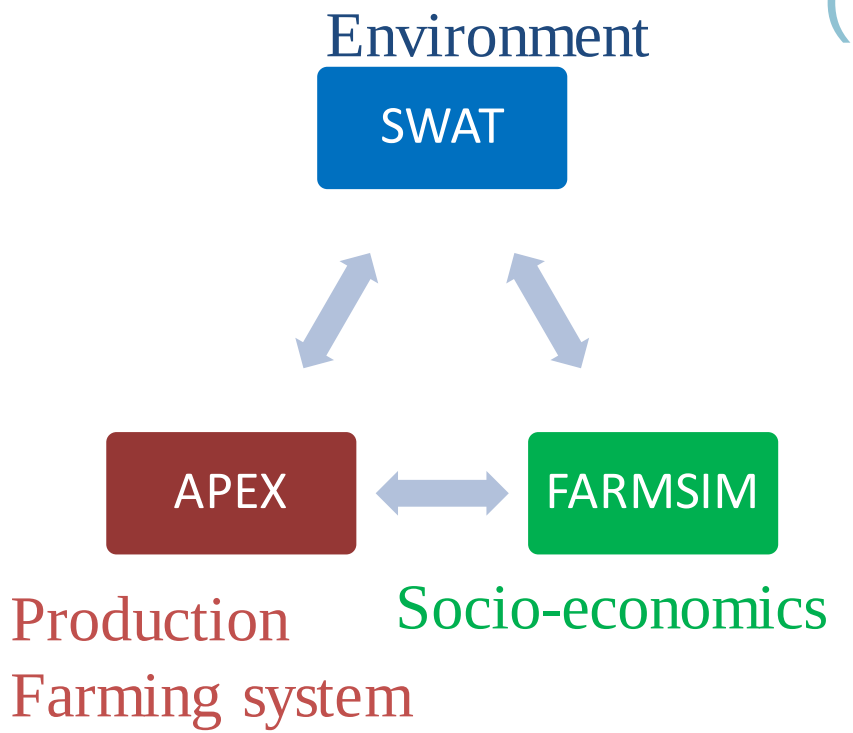
KEY QUESTIONS

- How much water/land is available for irrigation?
- How many farmers/households can it support?
- How sustainable is it?
  - Now into future
- What are the bottlenecks & opportunities?
  - technologies, social/cultural, economics
- What are the optimum mixes of interventions?
- What difference will it make?
  - income, health, and in the lives of people
- What changes in policy, practice and investments are necessary?
  - local, regional, national

INTEGRATED DECISION SUPPORT SYSTEM (IDSS)



- SWAT – analyze the potentials and impacts of SSI at the watershed scale
- APEX – analyze cropping systems at the field scale, and
- FARMSIM – assess economic & nutritional impacts at household level

APPLICATIONS OF IDSS?

- Ex-ante analysis
  - Relied on existing data from literature and secondary sources
  - Useful to study impacts of SSI
- Ex-post analysis
  - Used field data to fine-tune the ex-ante analysis
  - Helped to understand more on the impacts of SSI
  - Vital for gaps and constraint analysis
- Gaps and constraints analysis to SSI
  - Critical to identify mitigation strategies for the gaps and constraints
- Upscaling analysis
  - Uses data and lessons learned from the ex-post analysis
  - Useful to understand the potentials and impacts of SSI at national level
- Capacity building
  - IDSS models, and other demand-driven tools

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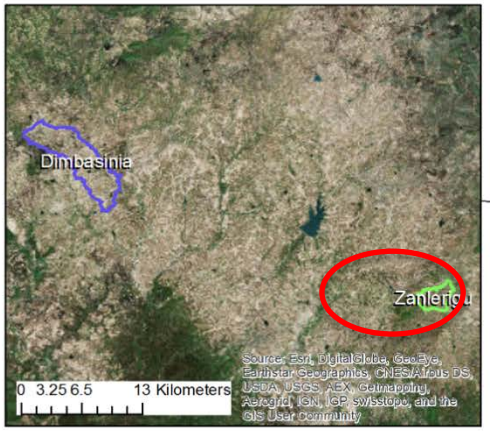
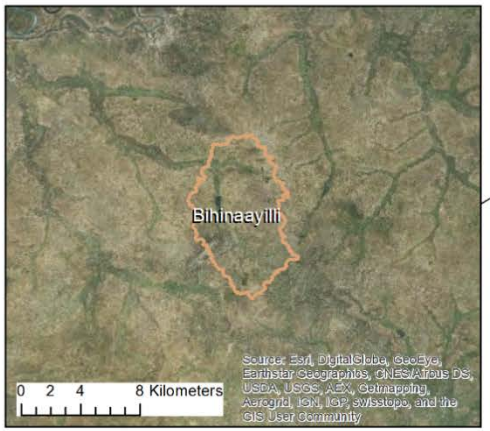
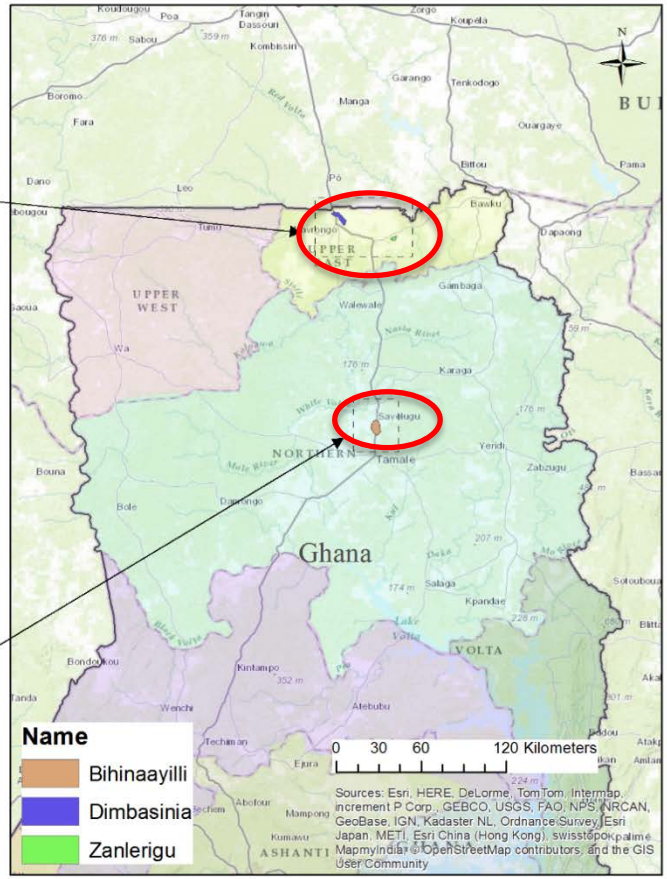
ILSSI RESEARCH SITES IN GHANA

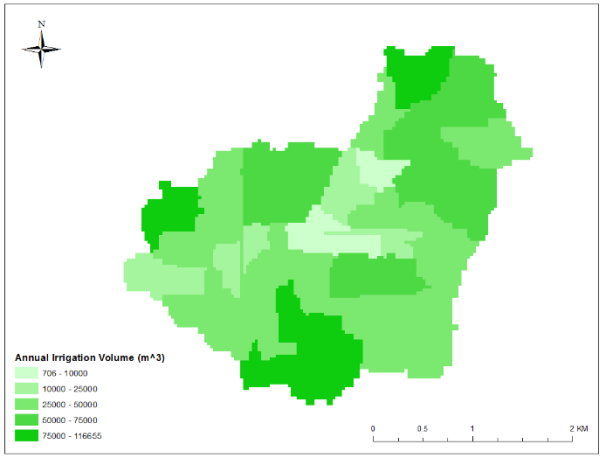






EX-POST CASE STUDY:

ZANLERIGU SITE



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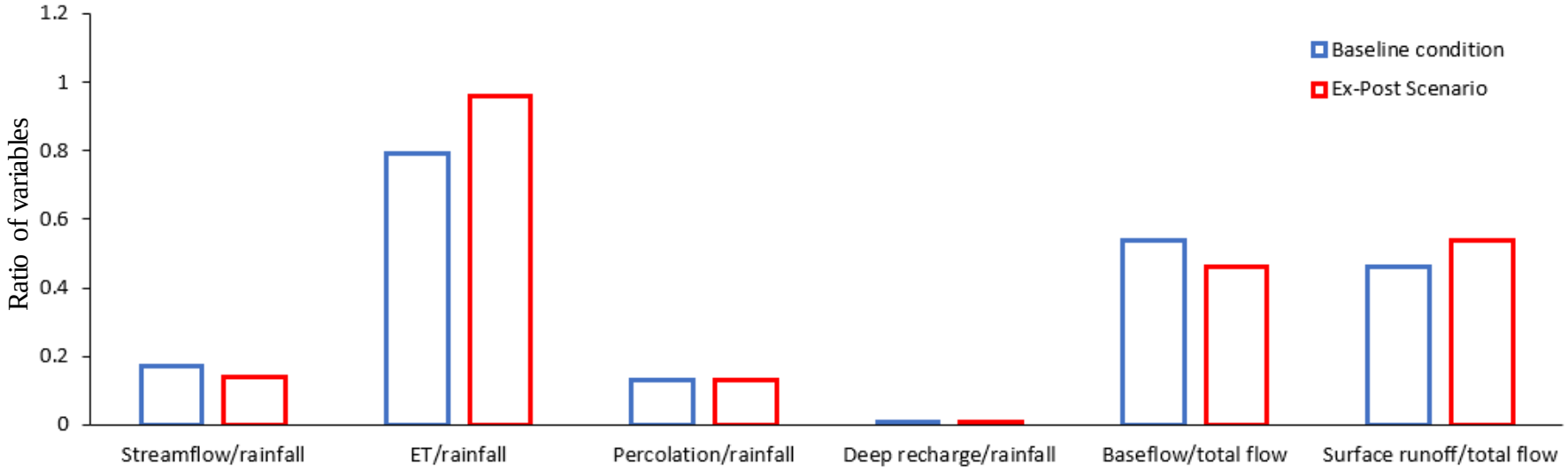
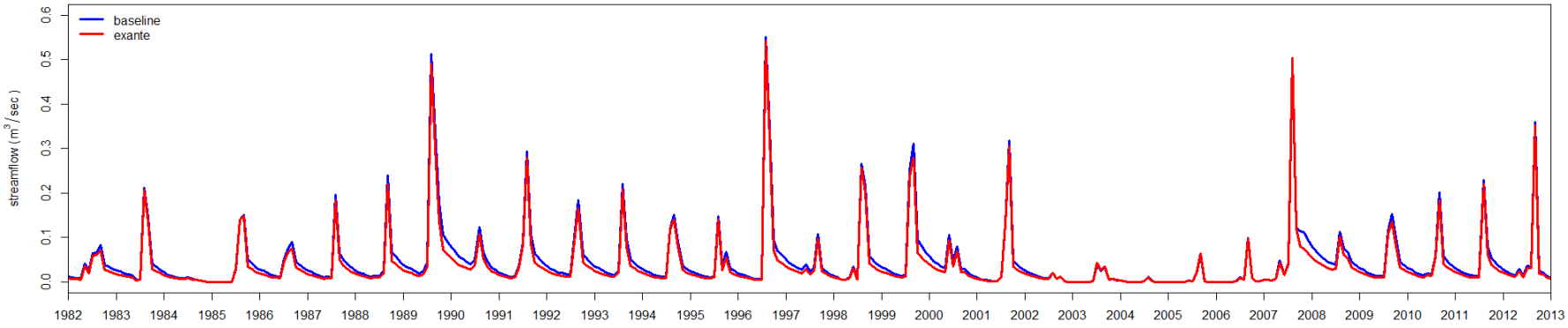
RESOURCE ASSESSMENT AT WATERSHED SCALE

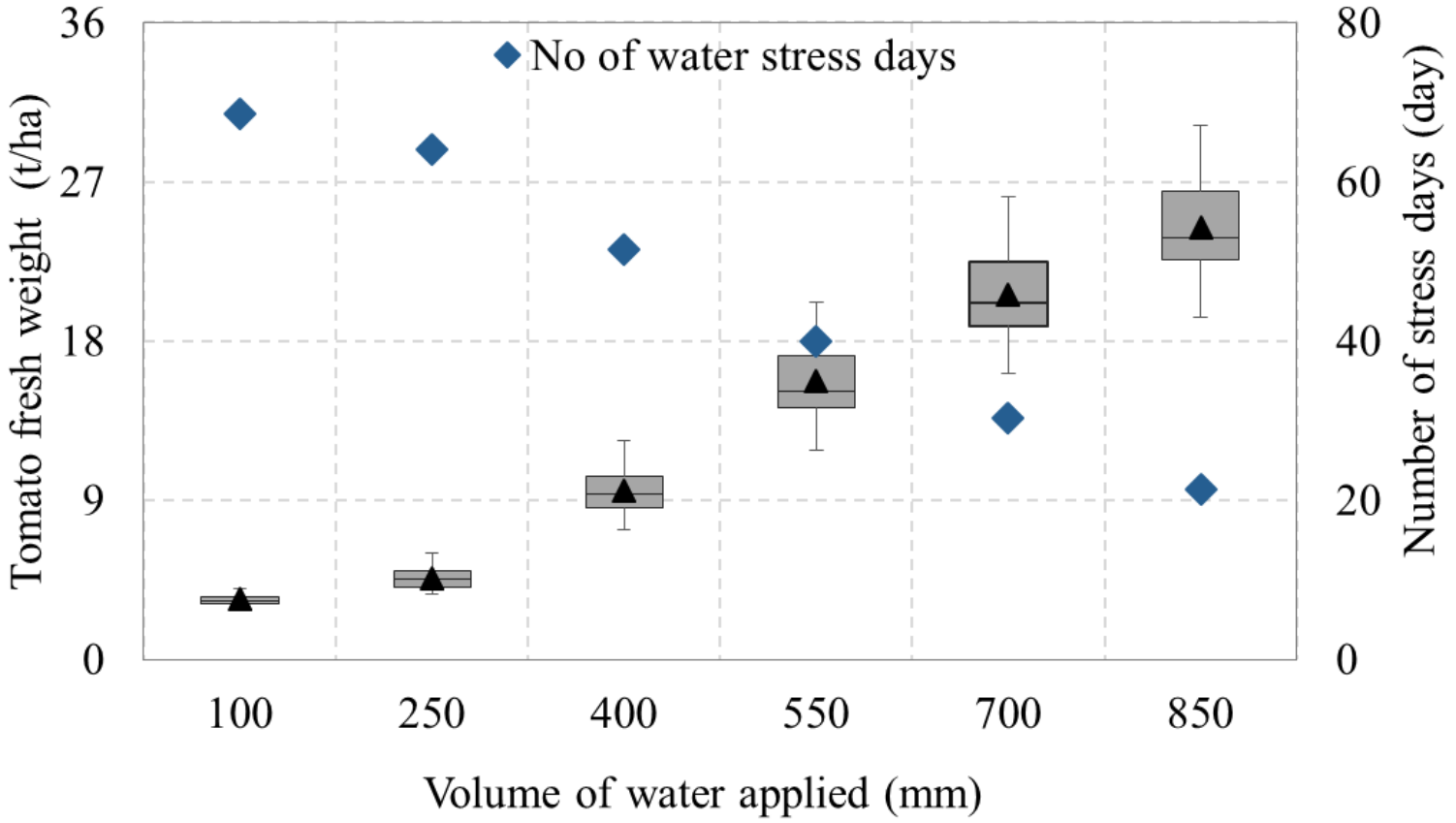
- Average annual rainfall = 970 mm (8.15 million m^3)
  - Groundwater recharge
    ~1.1 million m^3 over the watershed area of 840 ha
  - Surface runoff
    ~0.65 million m^3 over the watershed
- Amount of water required for dry season irrigation for tomato = 1.4 million m^3
  - ~125% of the **groundwater recharge**
- Groundwater recharge alone may not support irrigation for vegetables and fodder production in a sustainable manner.

IMPACTS OF SSI AT THE WATERSHED SCALE

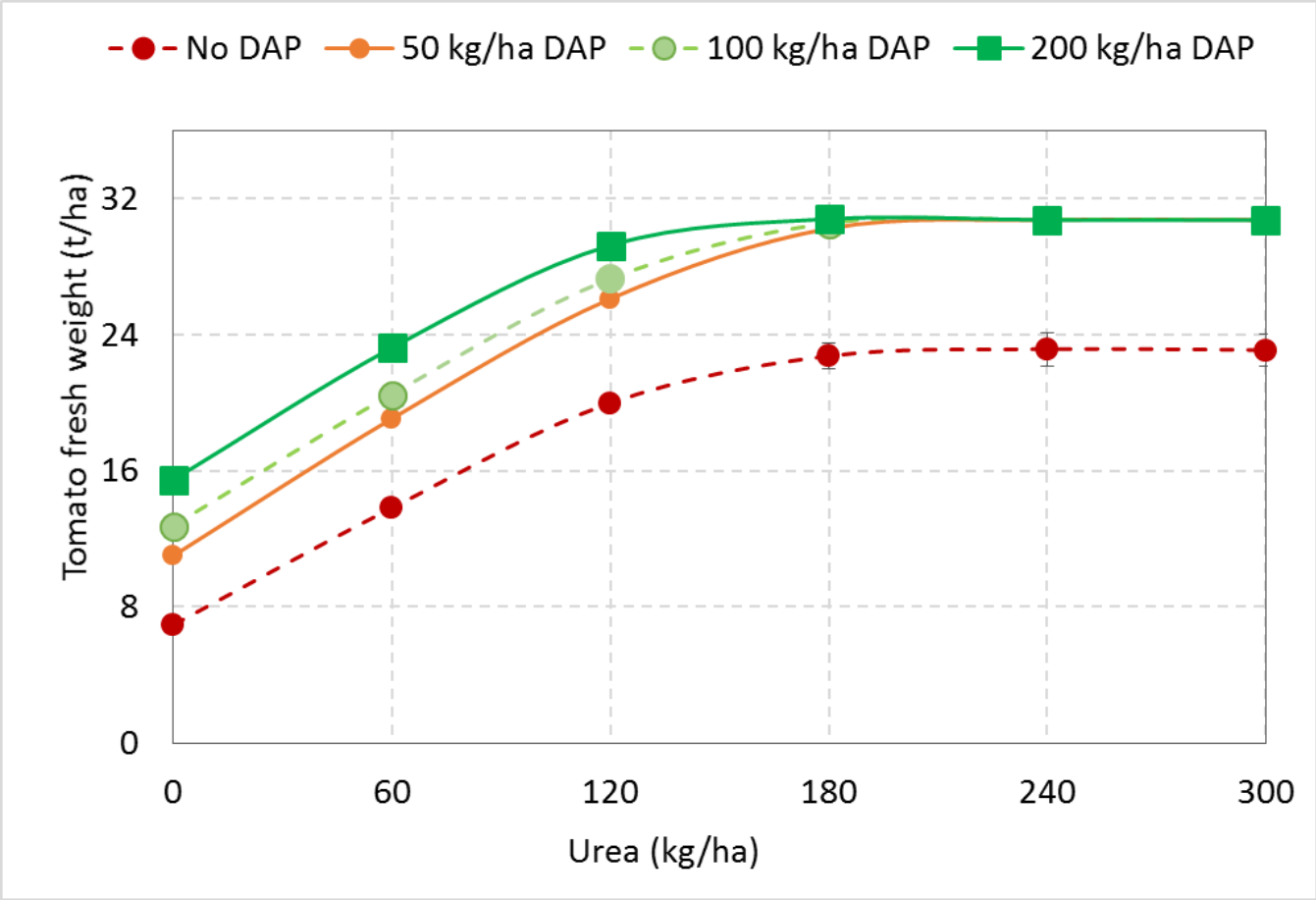




WATER USE FUNCTION OF TOMATO



FERTILIZER USE EFFICIENCY OF TOMATO



ECONOMIC AND NUTRITIONAL RESULTS

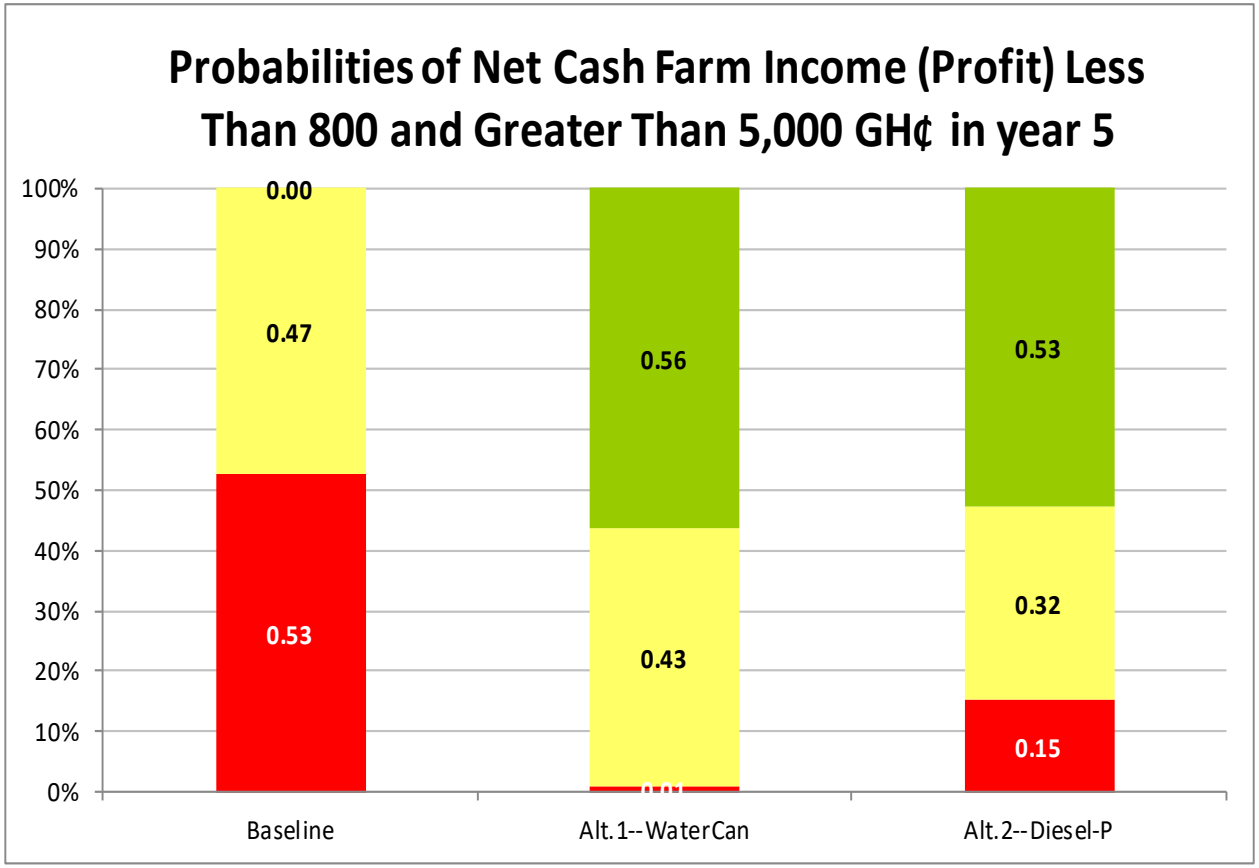
	Baseline	Alt. 1--WaterCan	Alt. 2--Diesel-P
Economics	Averages values in GHc /family in year 5		
Net present value	17,859	38,107	46,674
Avg. net profit	824	5,559	5,841
% change profit: Alt to Baseline		**574%**	**608%**
Benefit-Cost Ratio: Alt/Baseline		**2.8**	**1.4**

Nutrition	Min. required	Averages daily nutrients in year 5		
Energy (calories/AE)	1,750	1967	2239	2475
Proteins (grs/AE)	41	50.6	73.2	90.0
Fat (grs/AE)	39	**24.5**	**26.0**	**27.2**
Calcium (grs/AE)	1	**0.4**	**2**	**3**
Iron (grs/AE)	0.009	0.015	0.037	0.052
Vitamin A (grs/AE)	0.0006	**0.00007**	**0.00017**	**0.00024**

Note:
Baseline: No or minimal irrigation;
Alt.1--WaterCan: Watering Can used in optimally irrigated systems
Alt.2--Diesel-P: Diesel pump used in optimally irrigated systems
AE = Adult Equivalent
For economic variables: numbers in green show increase while those in red show decrease
For nutrition variables: numbers in red show quantities of nutrients intake < minimum required

Observation: lack of a variety of food consumed may be the cause of nutritional deficit. However we see a tremendous increase in Ca intake due to amaranth consumption

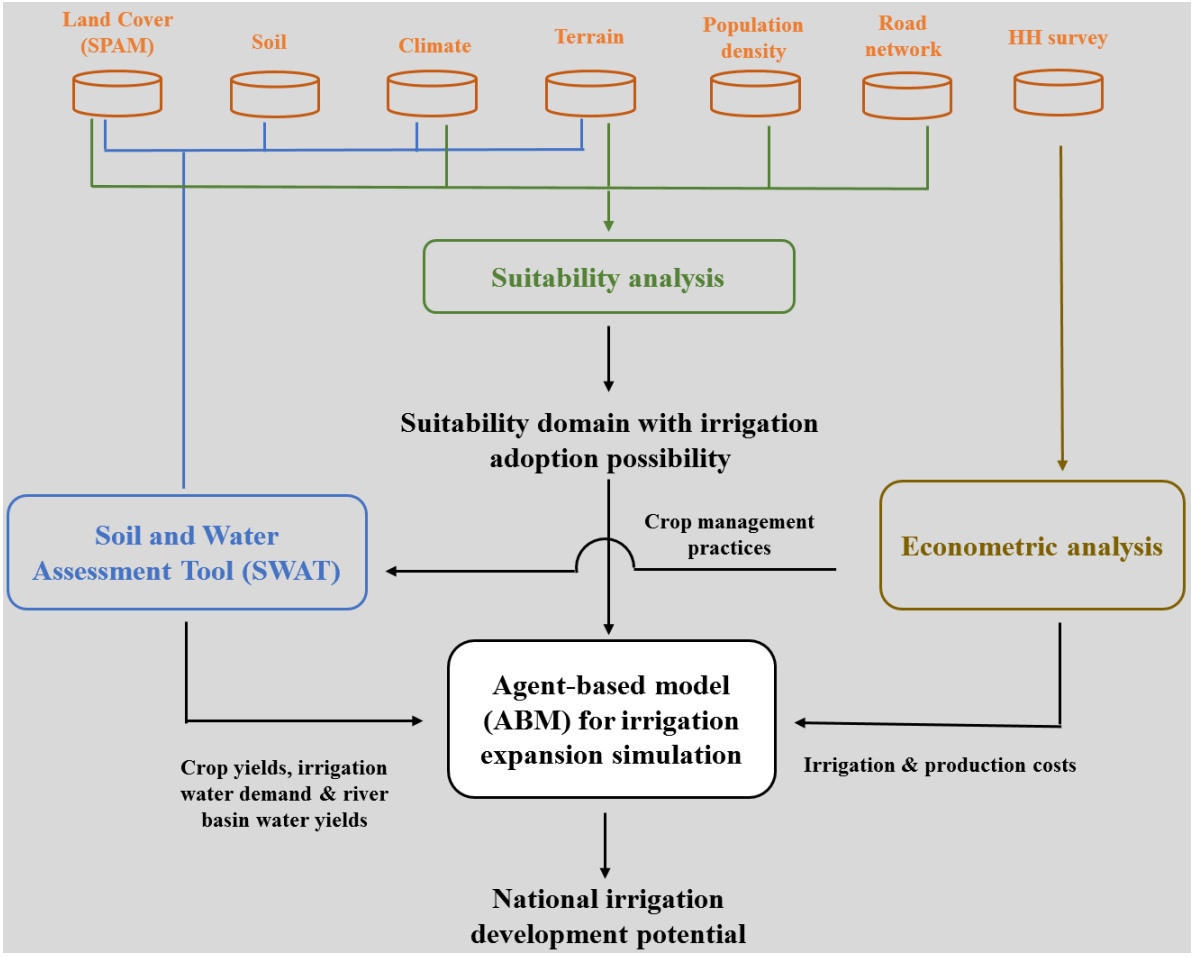
ECONOMIC AND NUTRITIONAL RESULTS



PLANNING AND EVALUATION OF SMALL SCALE IRRIGATION AT NATIONAL SCALE

- ILSSI research showed SSI improves agricultural production, environmental sustainability and household income & nutrition **at the household level**. The main questions though are:
  - What is the scale of investment for expanding SSI?
  - Where are strategic investment potential areas? and
  - What are the environmental and socio-economic impacts?
- Upscaling instrumental to address these and other questions.

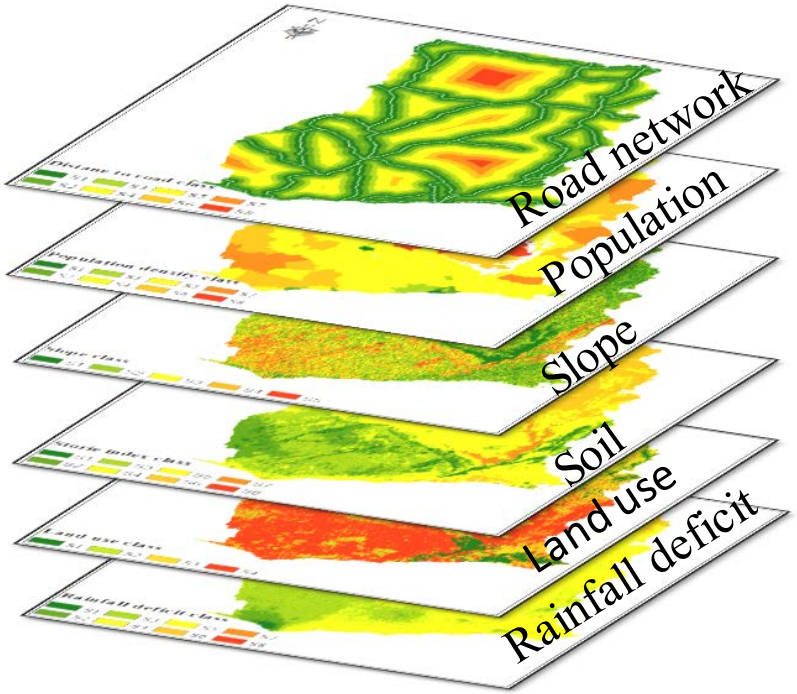
UPSCALING ANALYSIS FRAMEWORK

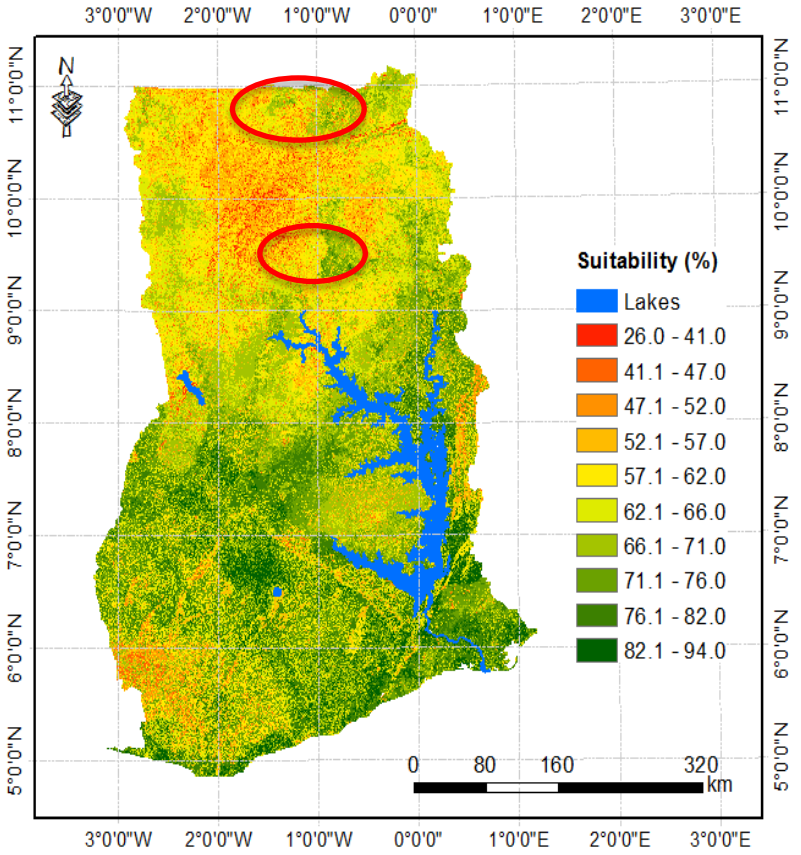


AGENT-BASED MODEL (ABM) OUTPUT

- Adoption probability and area of SSI in each geographic domain across the country,
- Environmental risk of water scarcity due to the adoption,
- Economic benefit for irrigators from the adoption, and
- Number of beneficiary population.

SUITABLE IRRIGABLE LAND

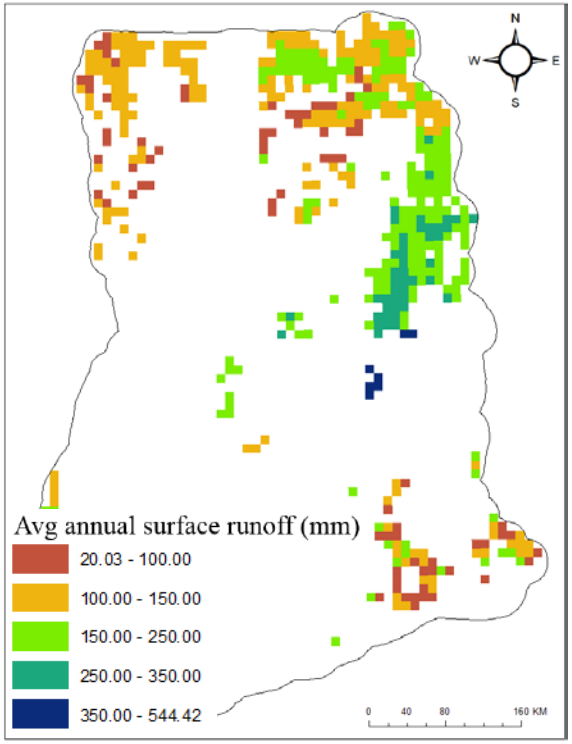


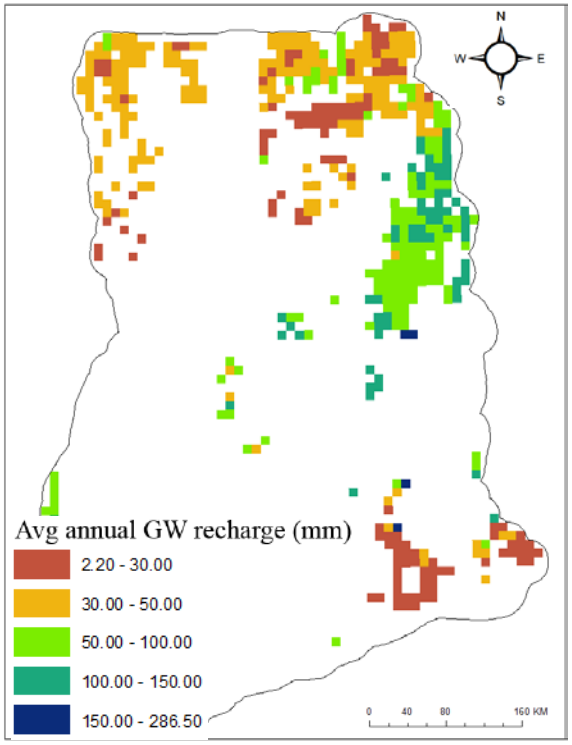


Overlay analysis

450,000 km^2 land is suitable at 85% level of suitability

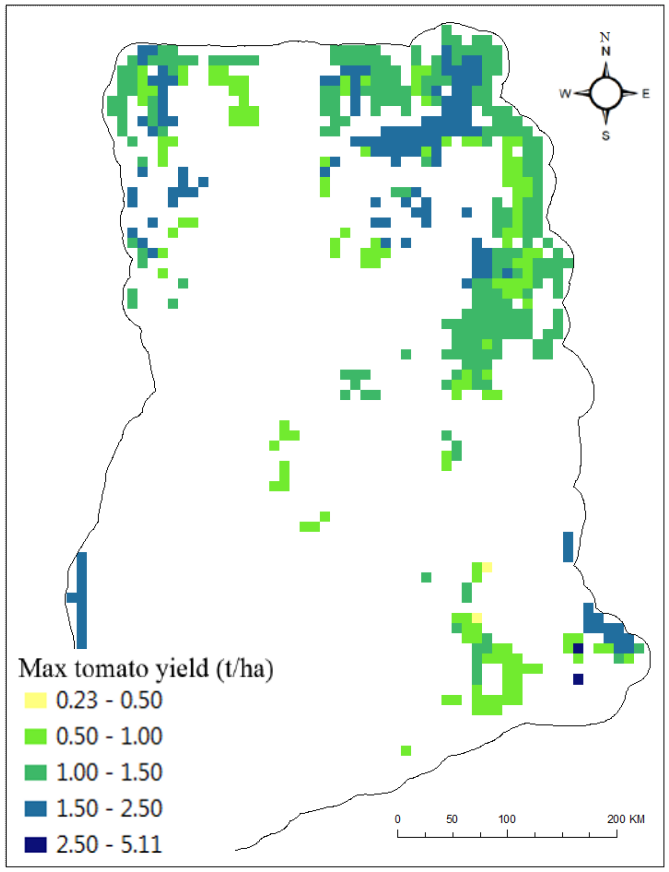
WATER RESOURCES POTENTIAL

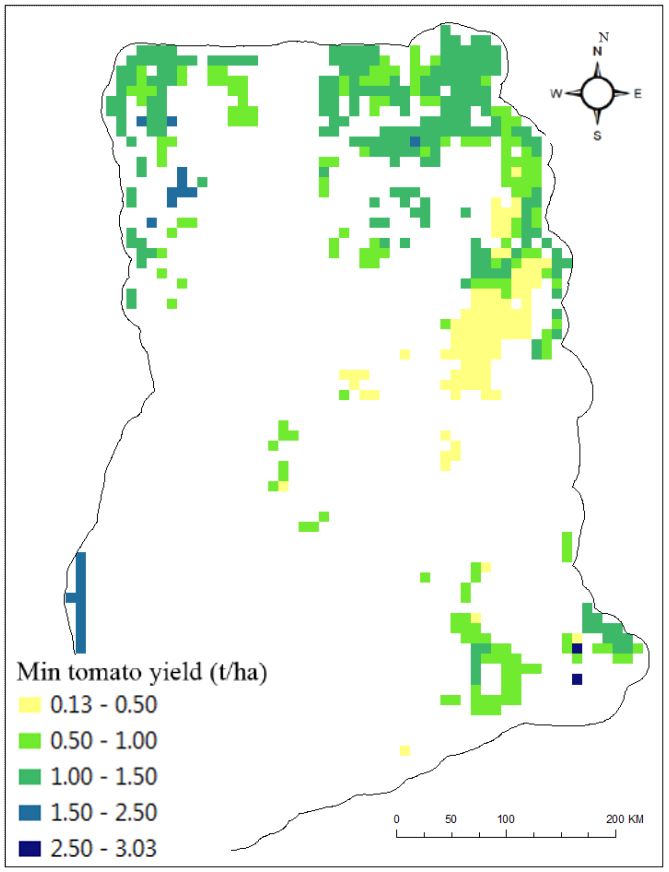




- A significant amount of surface runoff and groundwater recharge available at the northeastern and central part of the country to expand SSI.

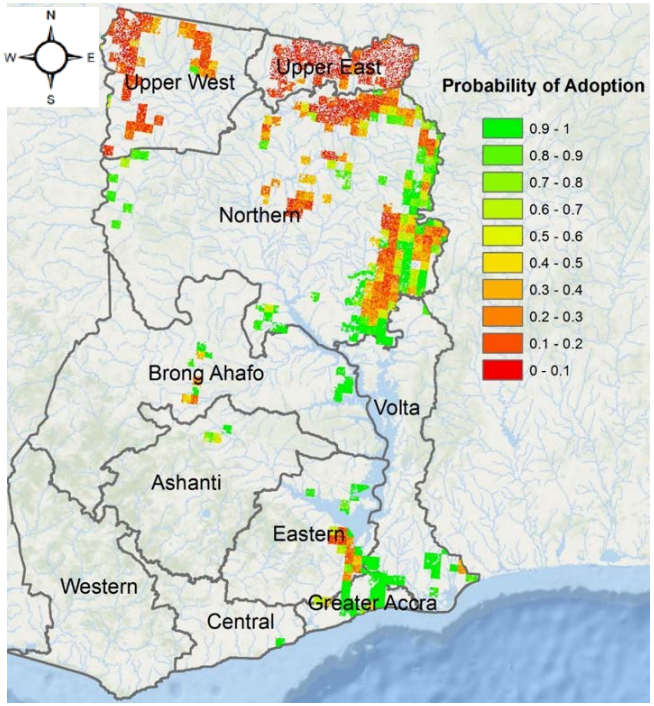
POTENTIAL FOR VEGETABLE PRODUCTION

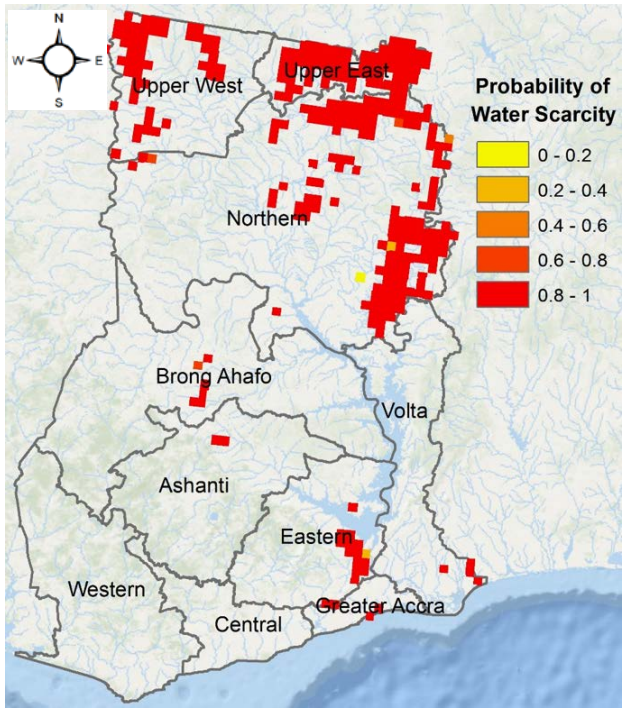




- The northeastern and central part of Ghana is productive for producing vegetables and fodder during the dry season

PROBABILITY OF IRRIGATION ADOPTION AND WATER SCARCITY





Potential area

~211 thousands ha

Profits to farmers

~285 million USD/year

Number of beneficiaries

690 thousands people

- High adoption probability for SSI at the western part of Ghana, and
- SSI development may pose widespread water scarcity in Ghana.

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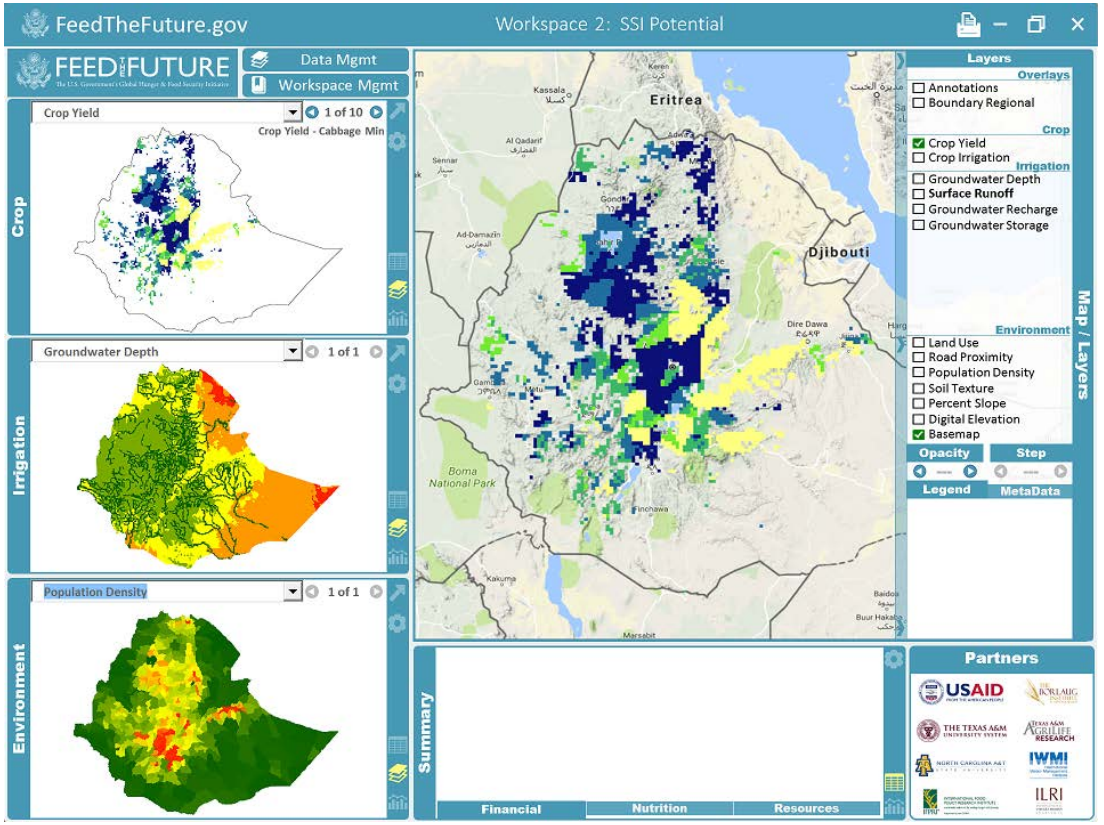
DEVELOPMENT OF DASHBOARD TO HARNESS THE POWER OF IDSS

- Alleviating end-users from being an expert in any specific models but to leverage from obtained results
- Planning and evaluation of SSI at multiple levels of scale
- Targeted end-users include:
  - Farmers and farmer organizations
  - Agents/practitioners that provide education and outreach



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CAPACITY DEVELOPMENT FROM IDSS

- Regular workshops (5 days) – 100M + 30F = 130
- Extended training for personnel from project countries (60 - 90 days)
- Graduate professional training in U.S. institutions (2-3 years)
- Continued support to stakeholders, graduate students, and CG systems (long term commitment)
- Institutionalization of IDSS (long term commitment)

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OVERALL OUTCOMES

- IDSS – helpful tool to identify strategies to mitigate gaps and constraints of SSI
- SSI and application of optimal fertilizer rates increased agricultural production and economic outcome
- The source of the water, and the most profitable technology were site specific
  - Labor – a major limitation on using low cost technology
  - Solar pumps – economical and workable
- Minimal to modest environmental impacts due to adoption of SSI
- Substantial potential for scaling SSI nationally, e.g. more than 690 thousands people benefited generating more than 285 million USD/year to farmers
- Key personnel trained with IDSS application, and efforts are in the making to institutionalize IDSS to educate more scientists and professionals to scale up SSI
- A dashboard developed for planning and evaluation of SSI

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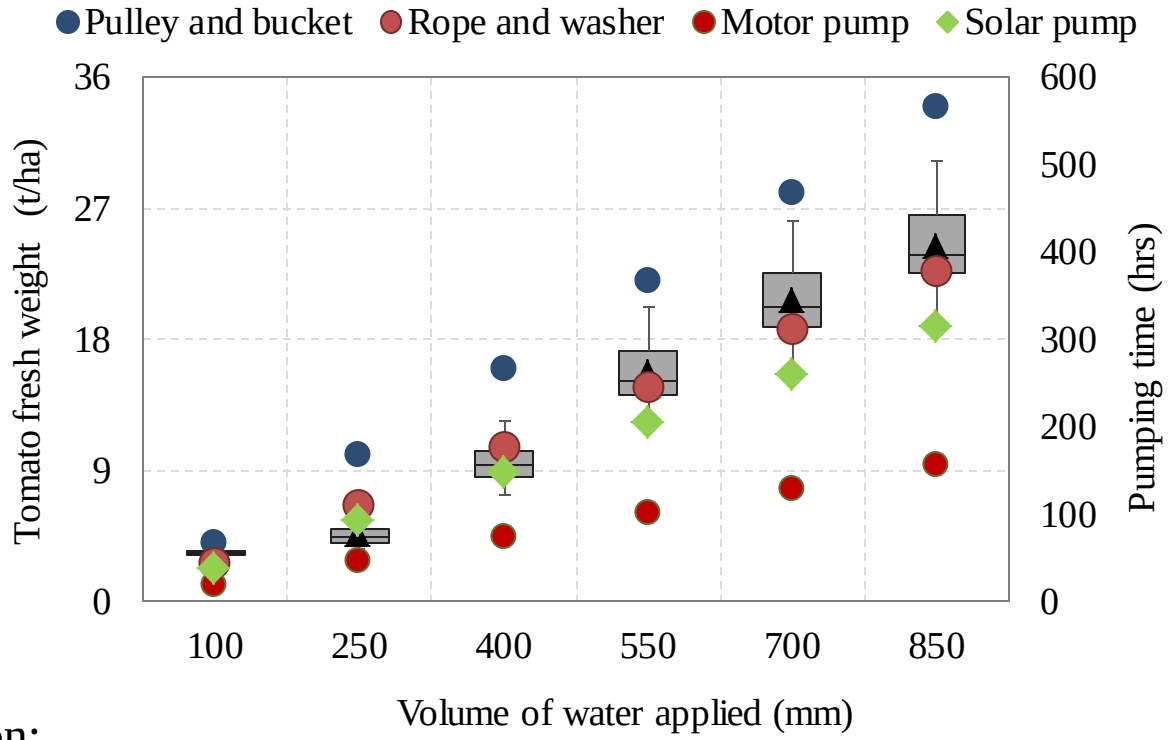
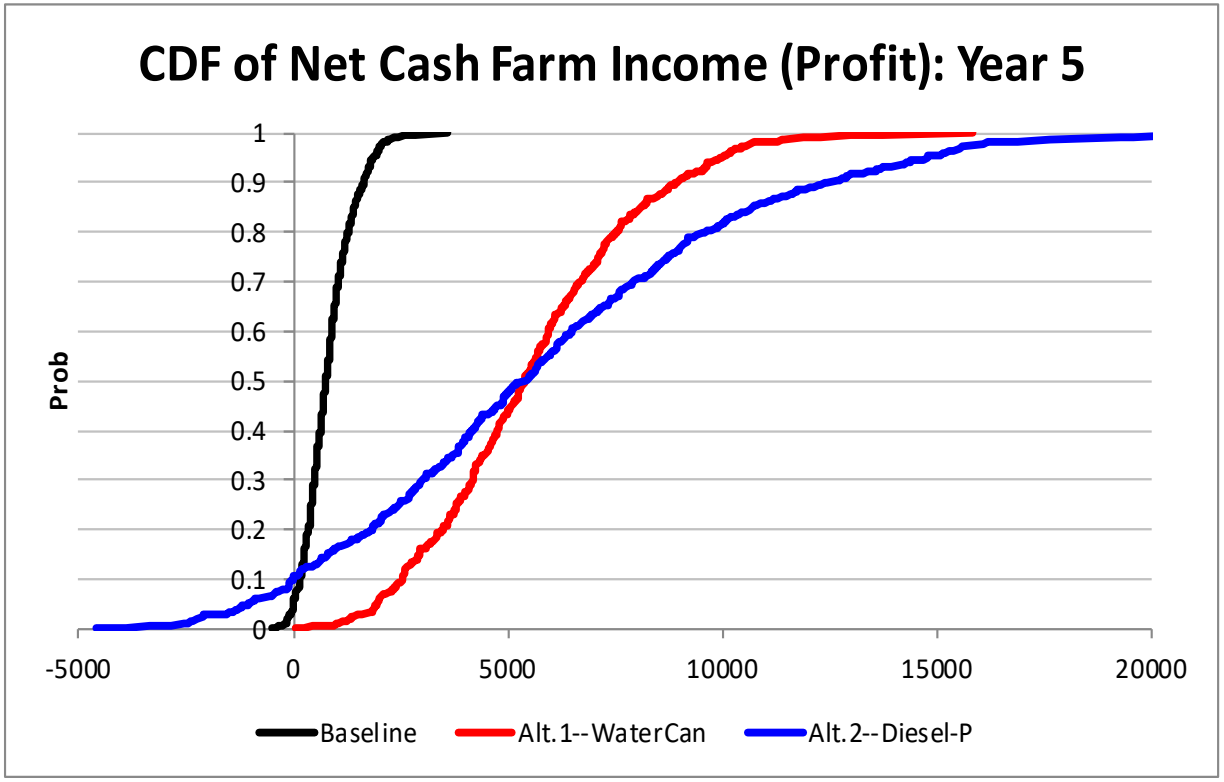
WATER USE FUNCTION AND PUMPING TIME OF TOMATO



Excessive irrigation:

- Limits irrigation expansion;
- Costs more time and money;

ECONOMIC AND NUTRITIONAL RESULTS



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PLANNING AND EVALUATION OF SMALL SCALE IRRIGATION AT NATIONAL SCALE

Farms to Nations using models

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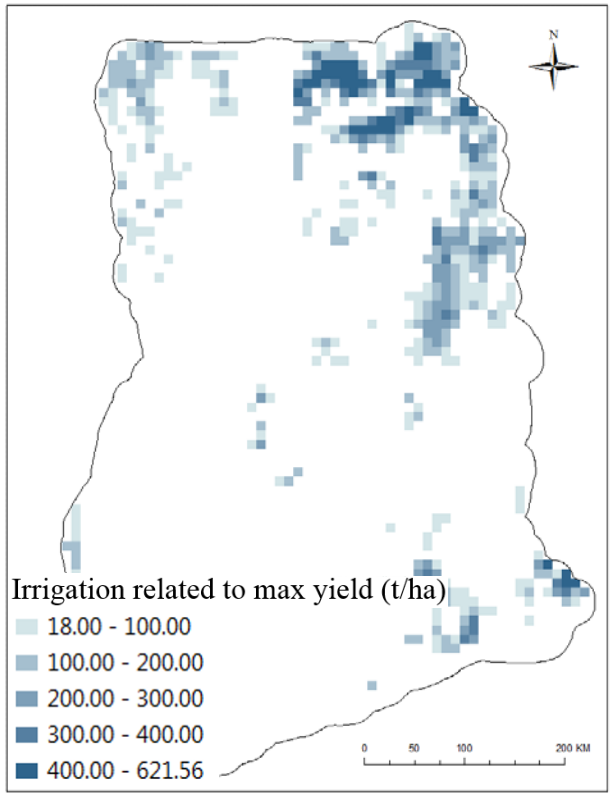
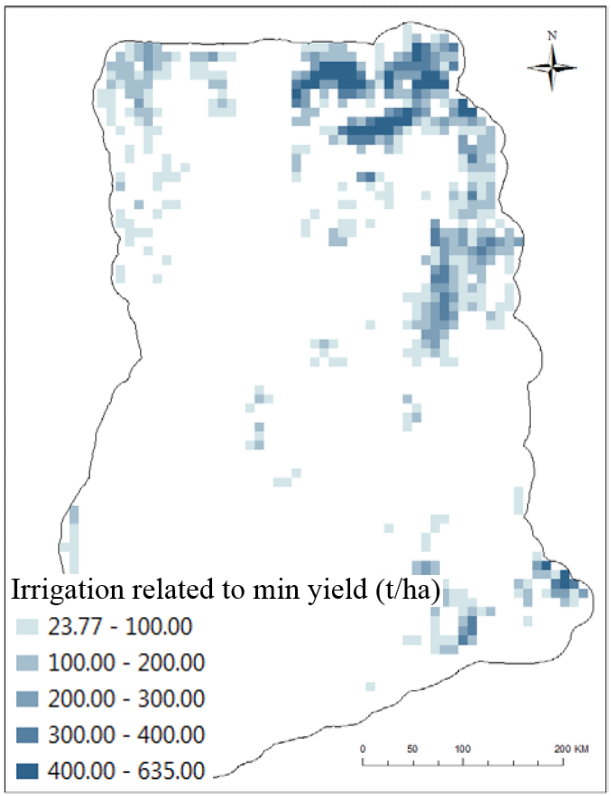
SPATIALLY EXPLICIT ESTIMATION

- Spatial Production Allocation Model (SPAM) to disaggregate the land use data into different crop types for SWAT,
- SWAT to estimate spatially explicit water availability, water consumption, crop yields, and environmental impacts, and
- ABM to estimate economic-cost benefit and water balance.

IRRIGATION FOR DRY SEASON CROPPING (E.G. TOMATO)





- Modest amount of irrigation needed to produce significant amount of vegetable and fodder during the dry season.

Irrigation related to min yield (t/ha)

ESTIMATED SMALL-SCALE IRRIGATION ADOPTION POTENTIAL IN GHANA

Region	Expected adoption area (thousand hectares)	Expected profits received by irrigators (million USD/yr)	Expected beneficiary population (thousand people)
Ashanti	5	5	15
Brong Ahafo	16	14	52
Central	1	2	4
Eastern	16	24	54
Greater Accra	3	6	11
Northern	115	133	377
Upper East	20	39	65
Upper West	27	48	89
Volta	7	13	23
Western	0	0	0
Total	211	285	690

- **~211 thousands ha** of land, **economically and biophysically** suitable for SSI development in Ghana,
- A net income of **~285 million USD/year** from the SSI adoption, benefiting 690 thousands people

IDSS TRAINING: DEMAND DRIVEN AND SOURCE OF INPUT TO ILSSI

- Based on user demand, the content of the training have been updated and additional workshop packages have been included, e.g.
  - IDSS-clinic,
  - Advanced SWAT Training,

- The workshops were important venue to exchange data and receive feedbacks on SSI practices in the project countries.

OVERALL OUTPUTS

- More than 50 reports and scientific articles produced - individual model per site, integrated site, and country reports, as well as scientific articles on the three ILSSI countries.
- Data for all the reports were shared to partners including through the Texas A&M University Library Dataverse. The data include:
  - Model outputs from SWAT, APEX and FARMSIM, which aid planning of SSI adoption,
  - Map for potential land suitability for SSI, and
  - Groundwater depth, Digital Elevation Model (DEM), high resolution soil and land use.
- Tools and models
  - SWAT/APEX/FarmSIM models, and QSWAT and Win-APEX interfaces
  - SSI Dashboard SSI for planning and evaluation at multiple levels of scale
  - Land suitability mapping tool, and
  - Weather data bias correction tool