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

Yihun Dile, Texas A&M University

ILSSI Stakeholder Consultation - International Livestock Research Institute, Addis Ababa - 24th May 2018

Photo: Desalegne Tadesse/IWMI

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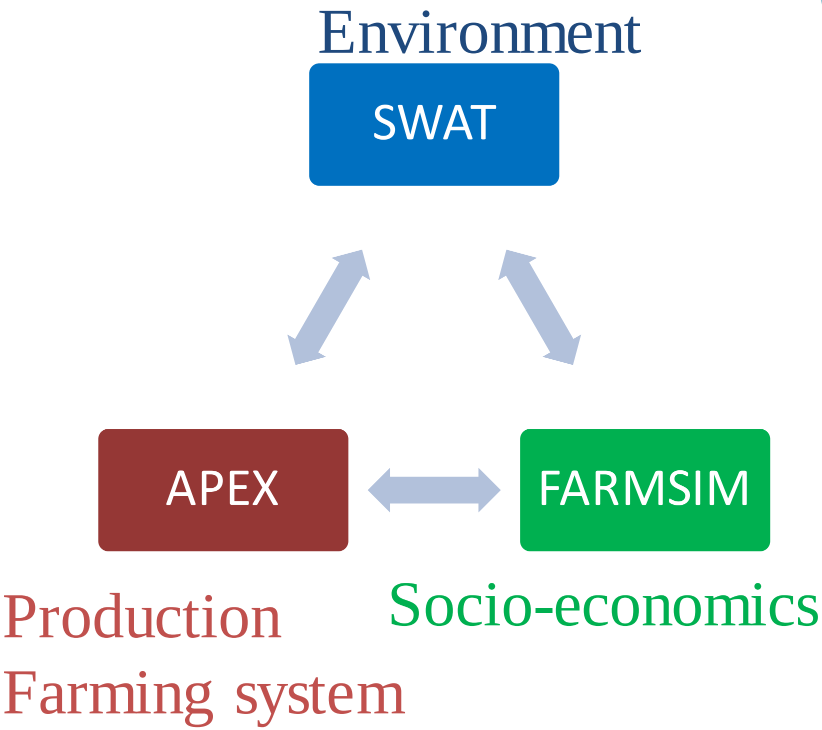
KEY QUESTIONS

- 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

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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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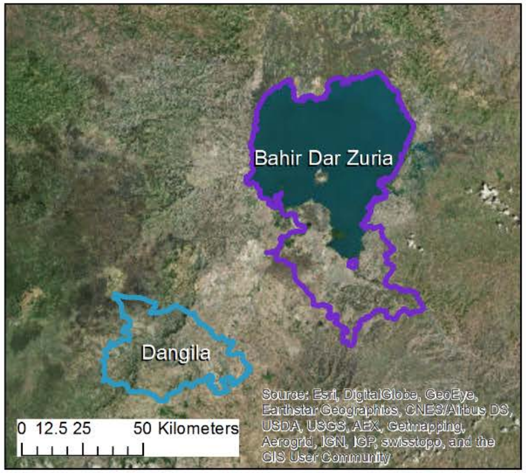
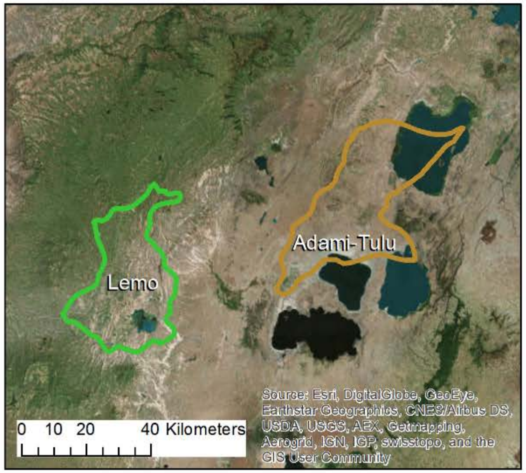
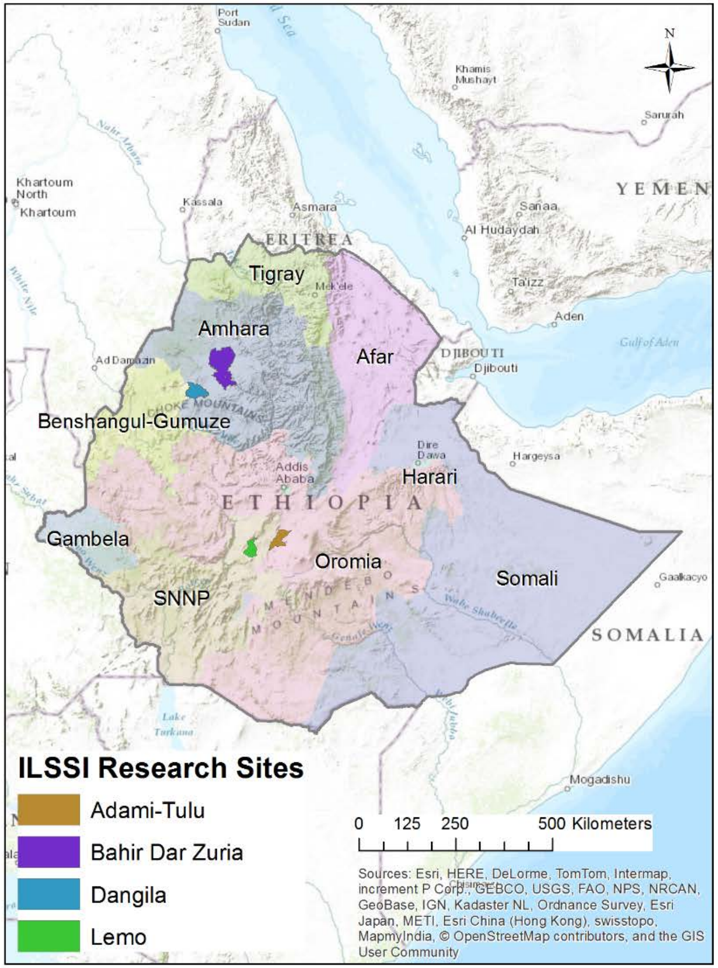
ILSSI RESEARCH SITES IN ETHIOPIA

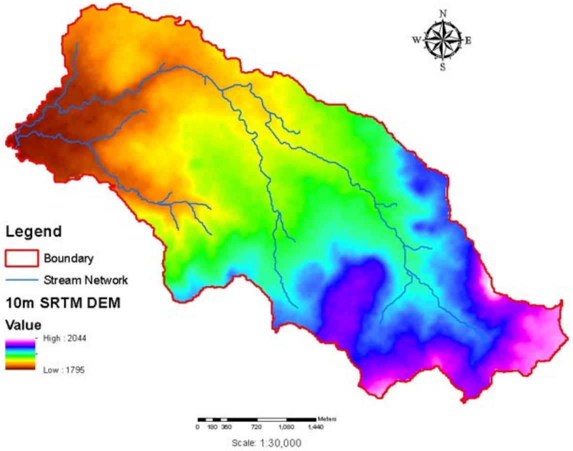






EX-POST CASE STUDY:

ROBIT SITE



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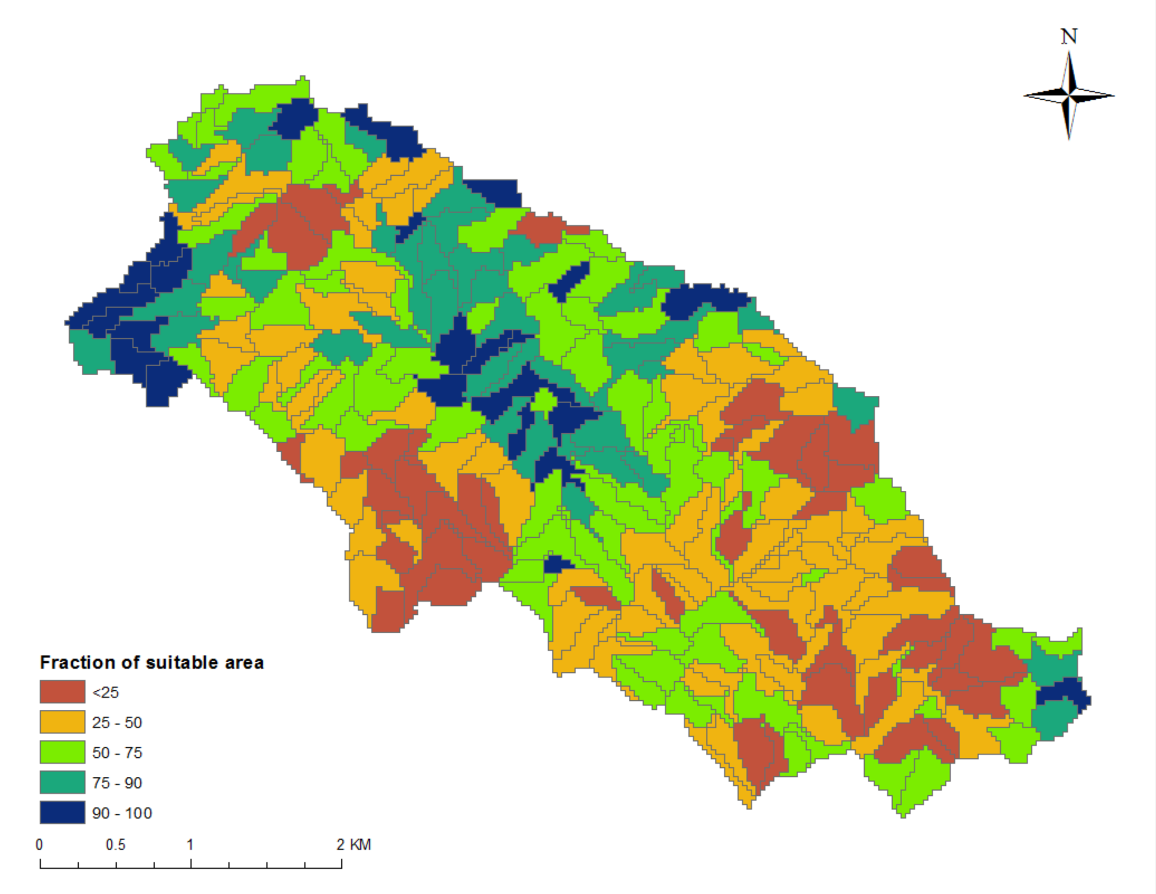
LAND SUITABILITY FOR IRRIGATION

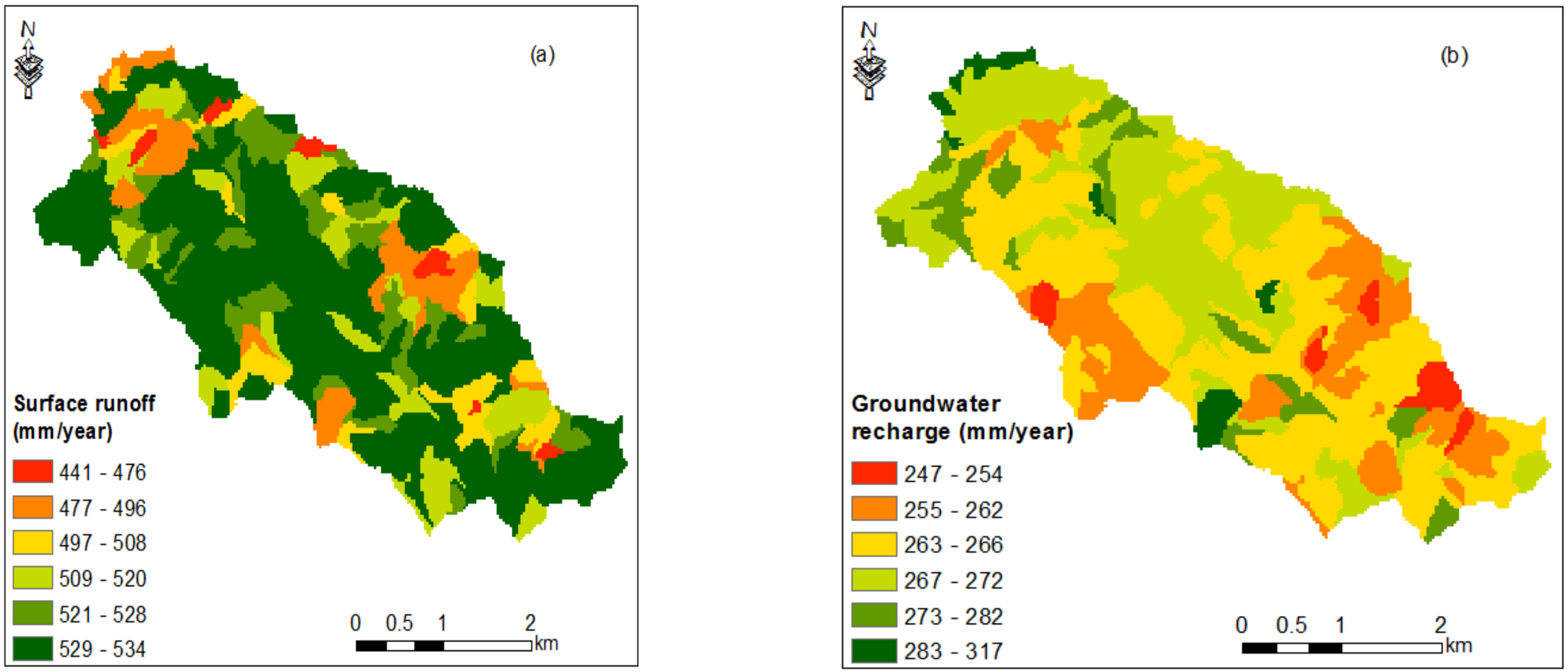


- ~57% of the watershed is suitable for irrigation.
- Major rainfed crops were maize, teff and finger millet.
- Dry season irrigated crops were tomato and onion.

RESOURCE ASSESSMENT AT WATERSHED SCALE: ROBIT CASE, ETHIOPIA

- Average annual rainfall = 1,400 mm
  - → groundwater recharge = 280 mm (~4,000,000 m^3 over the watershed)
  - → surface runoff = 520 mm (~7,000,000 m^3 over the watershed)
- Amount of water required for dry season irrigation for tomato = 1,500,000 m^3
  - → ~40% of the **groundwater recharge**
- At the watershed scale, groundwater recharge can support irrigation for vegetables (in suitable areas) in a sustainable manner.

ROBIT SURFACE RUNOFF AND SHALLOW GROUNDWATER RECHARGE



- estimating the water resource potential to determine irrigation potential at watershed scale.

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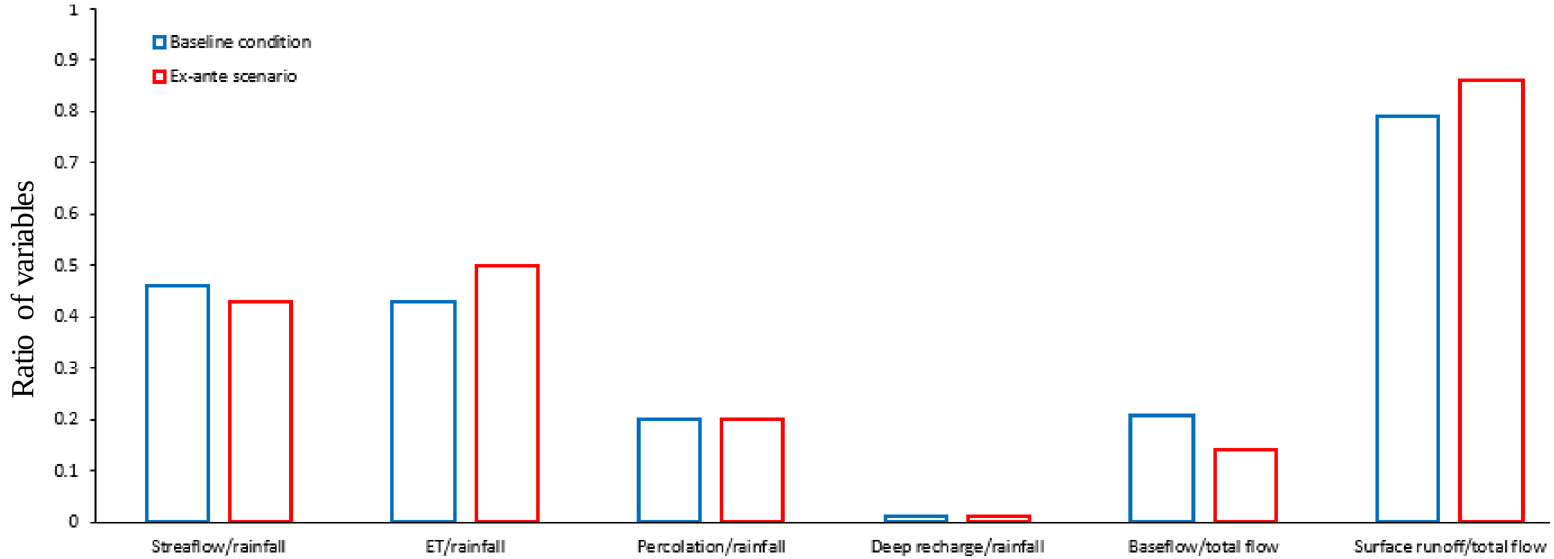
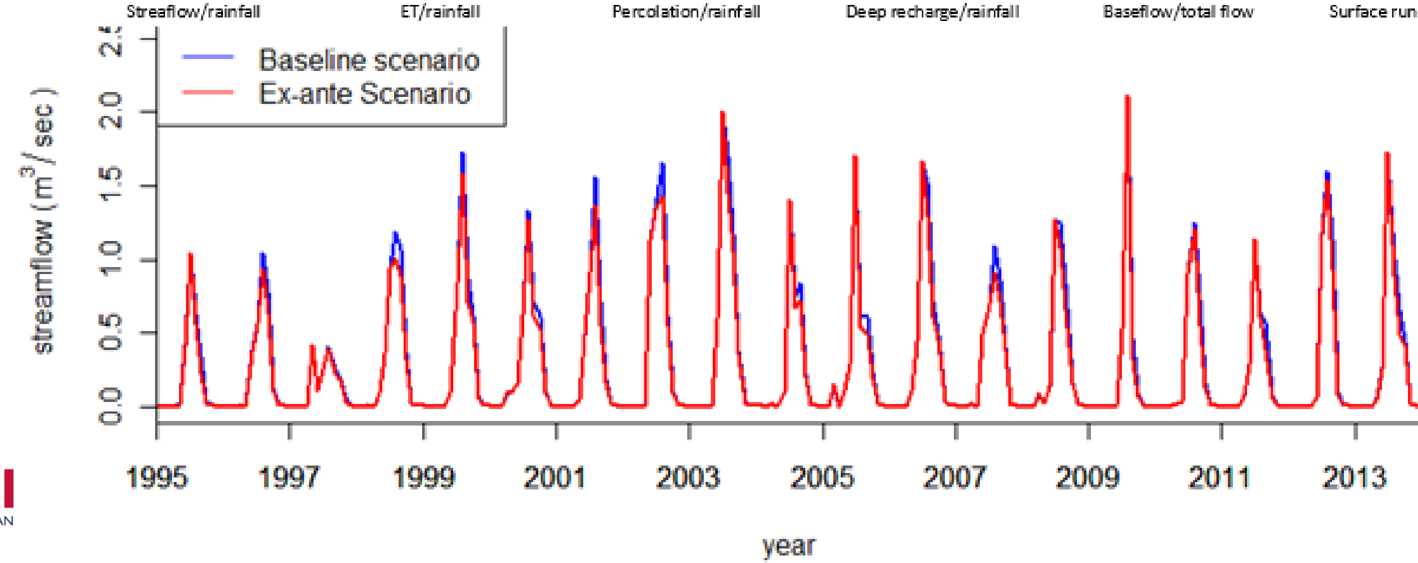
IMPACTS OF SSI AT THE WATERSHED SCALE





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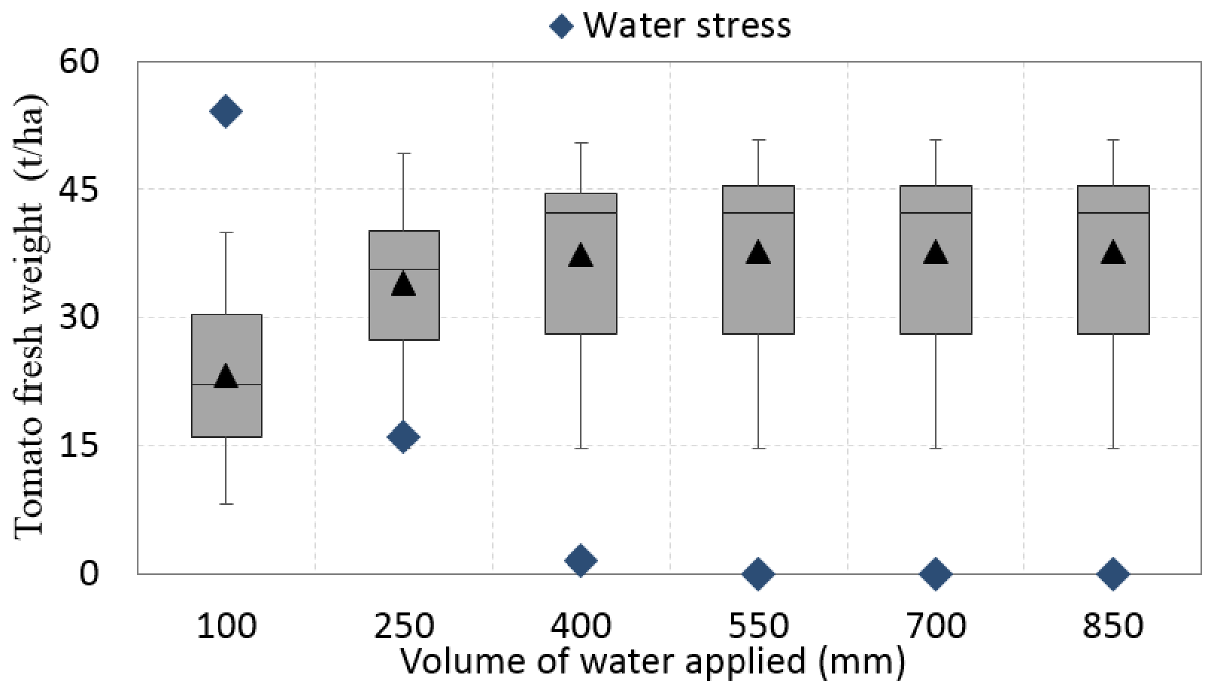
WATER USE FUNCTION OF TOMATO

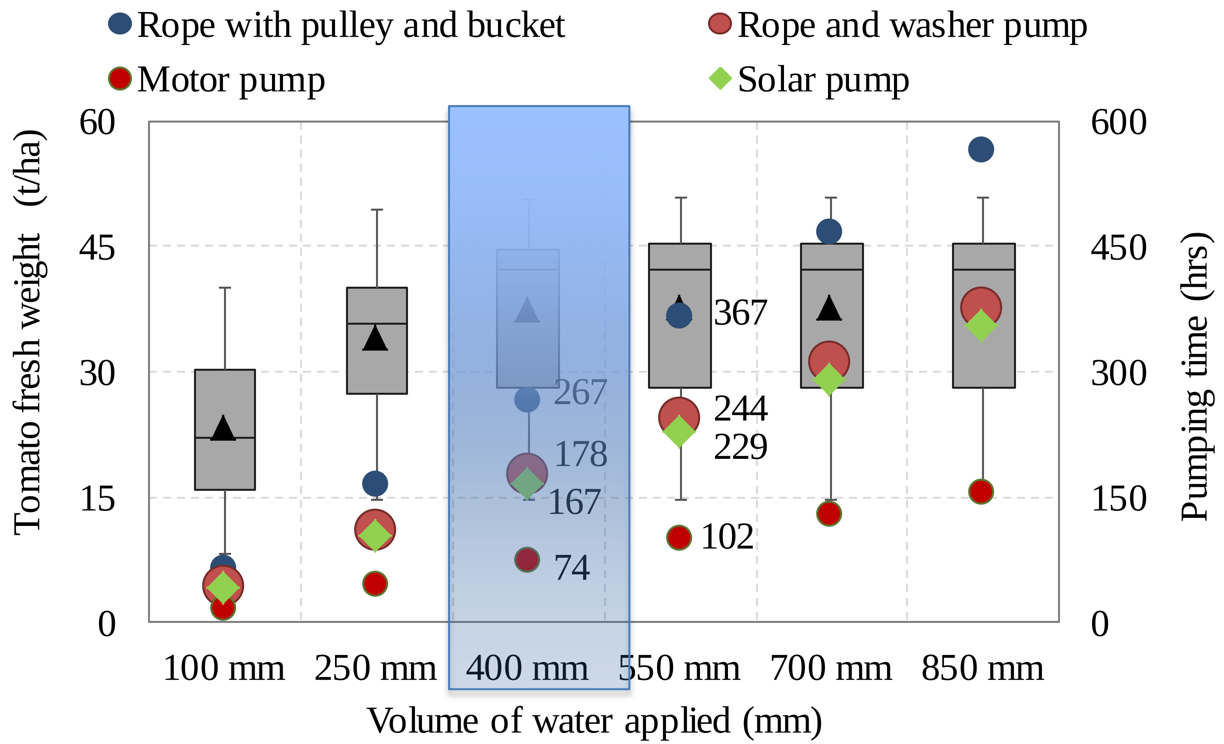
Season total (mm)	Application rate (mm/2-days)
100	1.4
250	3.5
400	5.7
550	7.8
700	9.9
850	12.1



- Average tomato yield ranges b/n 23-37 ton/ha depending on the irrigation amount
- Optimal water to maximize tomato yield is 400 mm/year, which is higher than the average annual shallow groundwater recharge.
- Water is a constraint if groundwater is the only source of irrigation.

WATER USE FUNCTION AND PUMPING TIME OF TOMATO

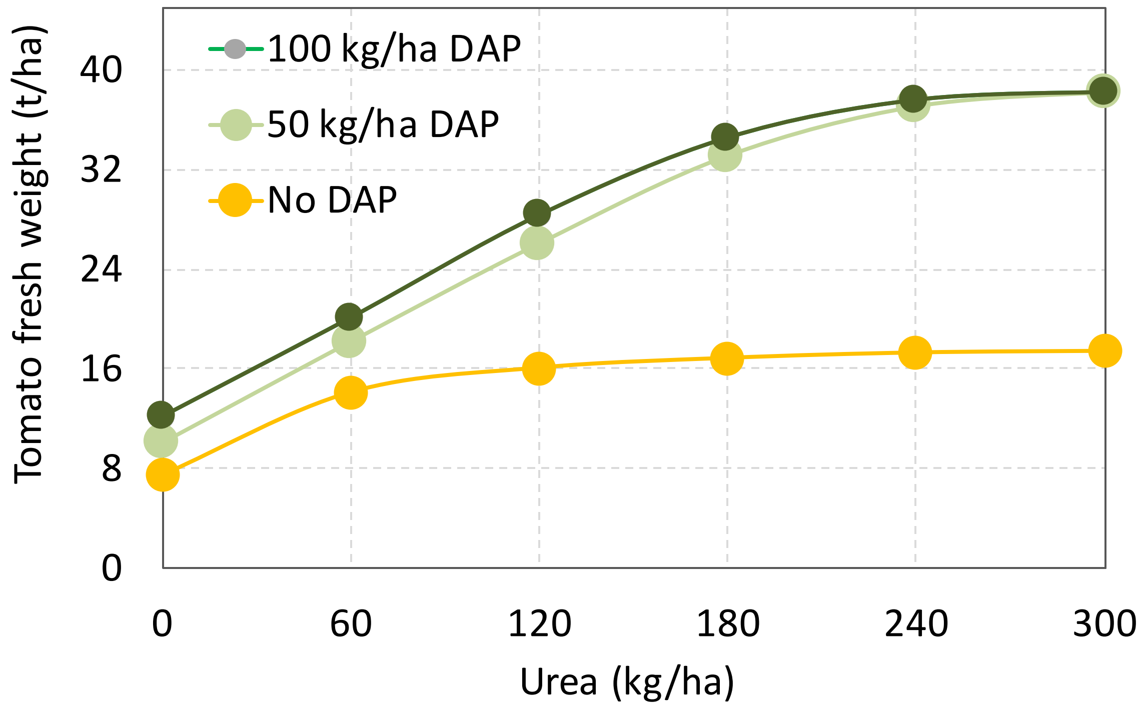
Technology	Pumping capacity (l/min)
Rope with pulley & bucket	10
Rope & washer pump	15
Solar pump	16
Motor pump	36



Over-irrigation:

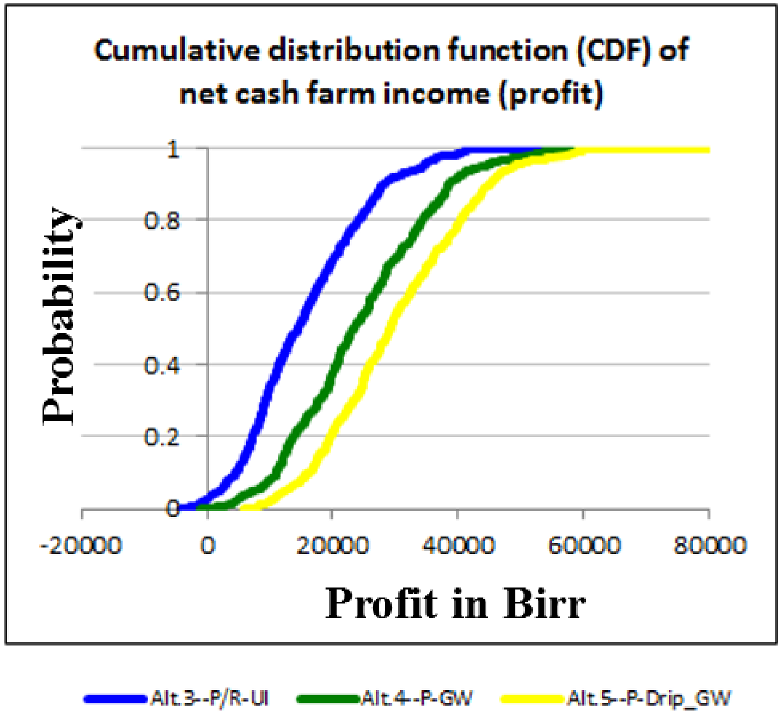
- Costs more time and money
- A threat to irrigation expansion

FERTILIZER USE EFFICIENCY OF TOMATO



- Optimal fertilizer use is at 200-250 kg/ha Urea with 50-100 kg/ha DAP,
- Farmers' practice is far lower and of different proportional rates.

GAP AND CONSTRAINT ANALYSIS: SSI TECHNOLOGY

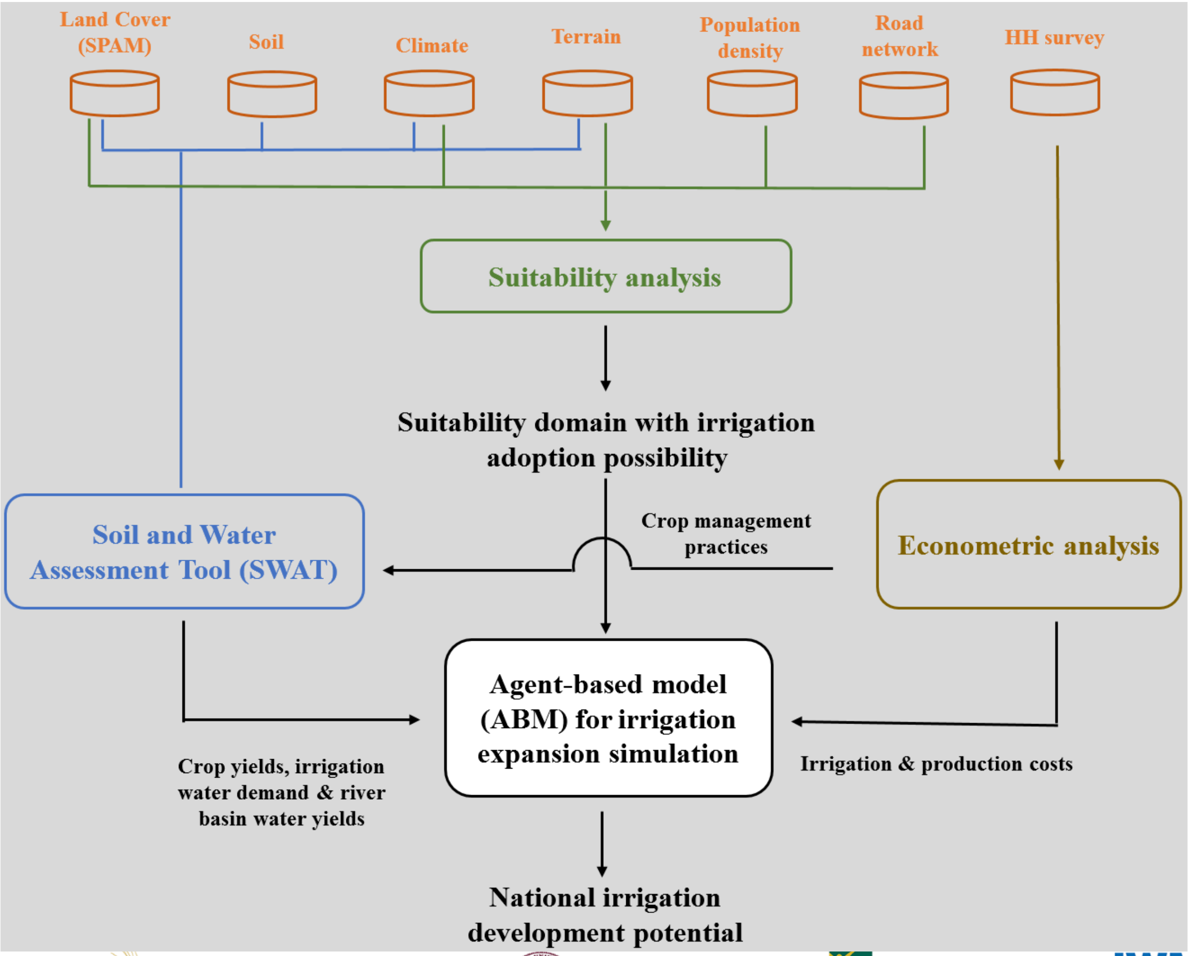


- Description of the scenarios
  - **Alt.3--P-UI**: Pulley with 100 mm in furrow irrigation
  - **Alt.4--P-GW**: Pulley with 250 mm in furrow irrigation
  - **Alt.5--P_Drip-GW**: Pulley with 250 mm in drip irrigation
- Alt. 5 is more profitable and efficient in water limited situation
- Alt.3 (in extremely dry situation) is lowest ranking in profitability

PLANNING AND EVALUATION OF SMALL SCALE IRRIGATION AT NATIONAL SCALE

- **ILSSI field research** showed SSI improves agricultural production, and household income & nutrition without compromising environmental sustainability. The main questions though are:
    - What is the scale of investment for expanding SSI?
    - Where are strategic potential investment areas? and
    - What are the environmental and socio-economic impacts?
- Upscaling instrumental to address these and other questions.

UPSCALING ANALYSIS FRAMEWORK



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.

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.

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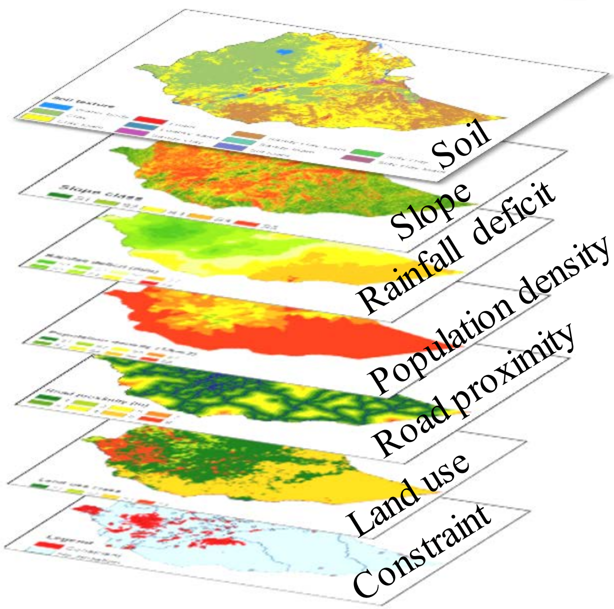
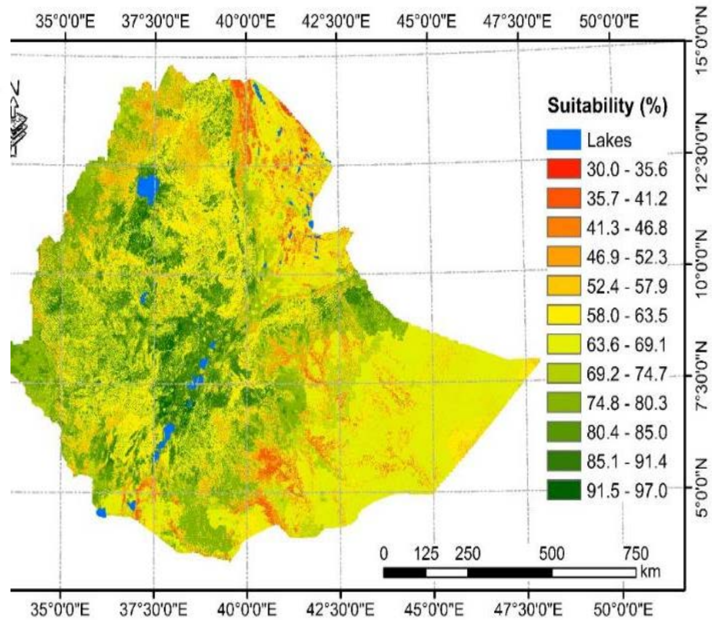
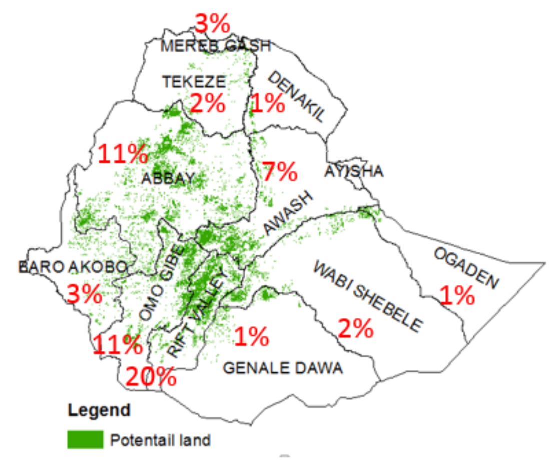
SUITABLE IRRIGABLE LAND



Overlay analysis



Preliminary Suitability Map
12% rainfed land = 6.0 million ha



8% of the suitable land could be irrigated with the shallow groundwater

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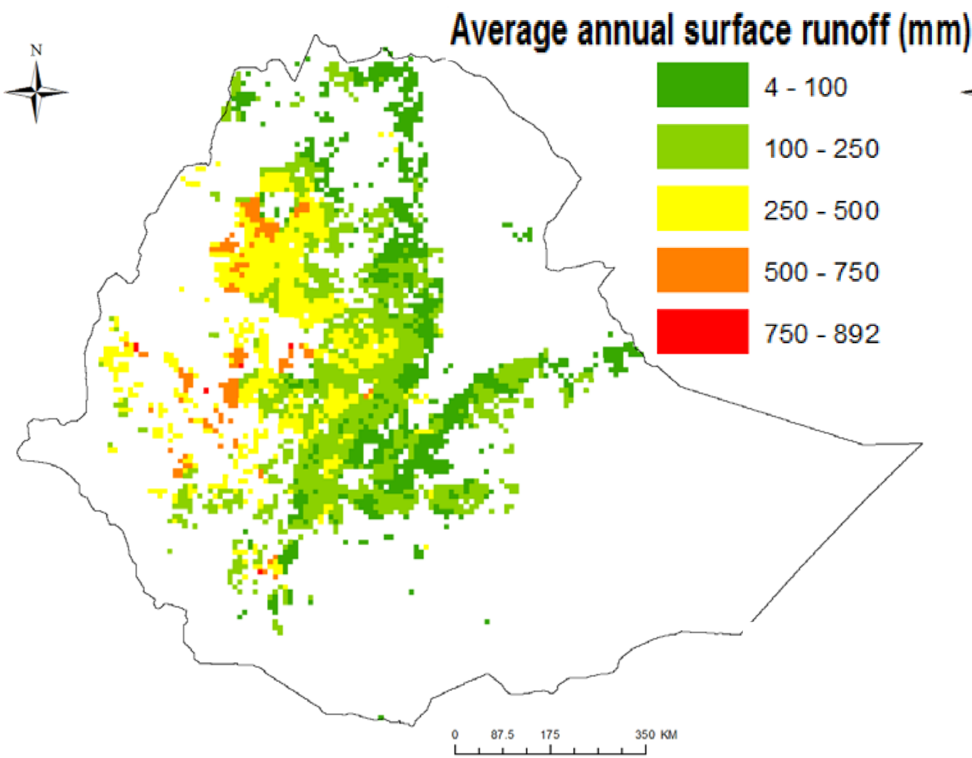
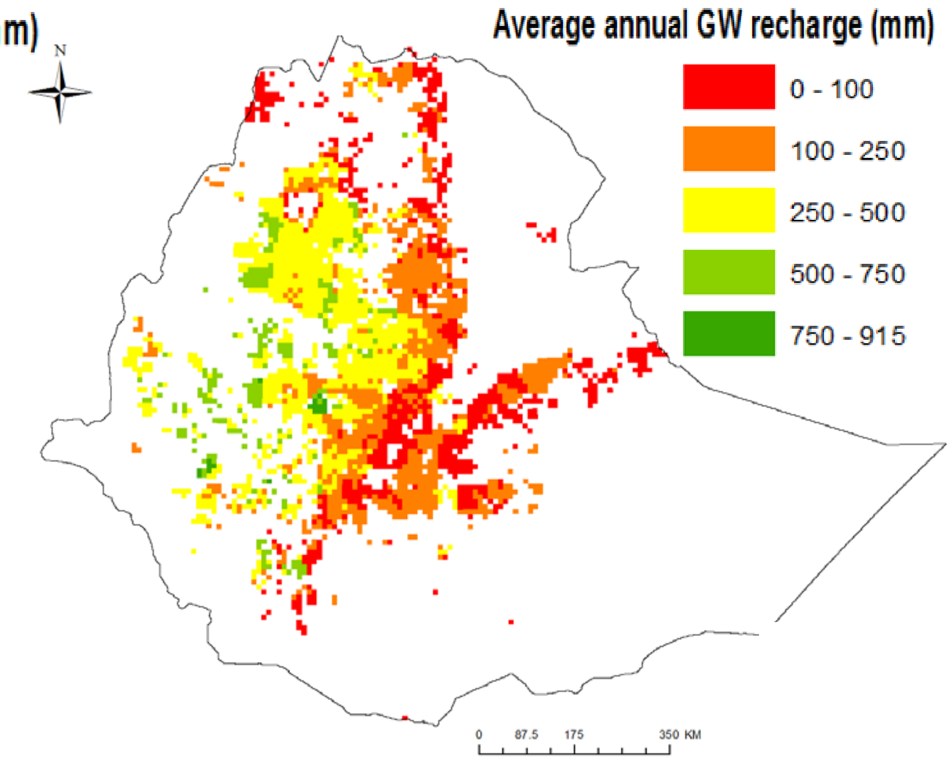
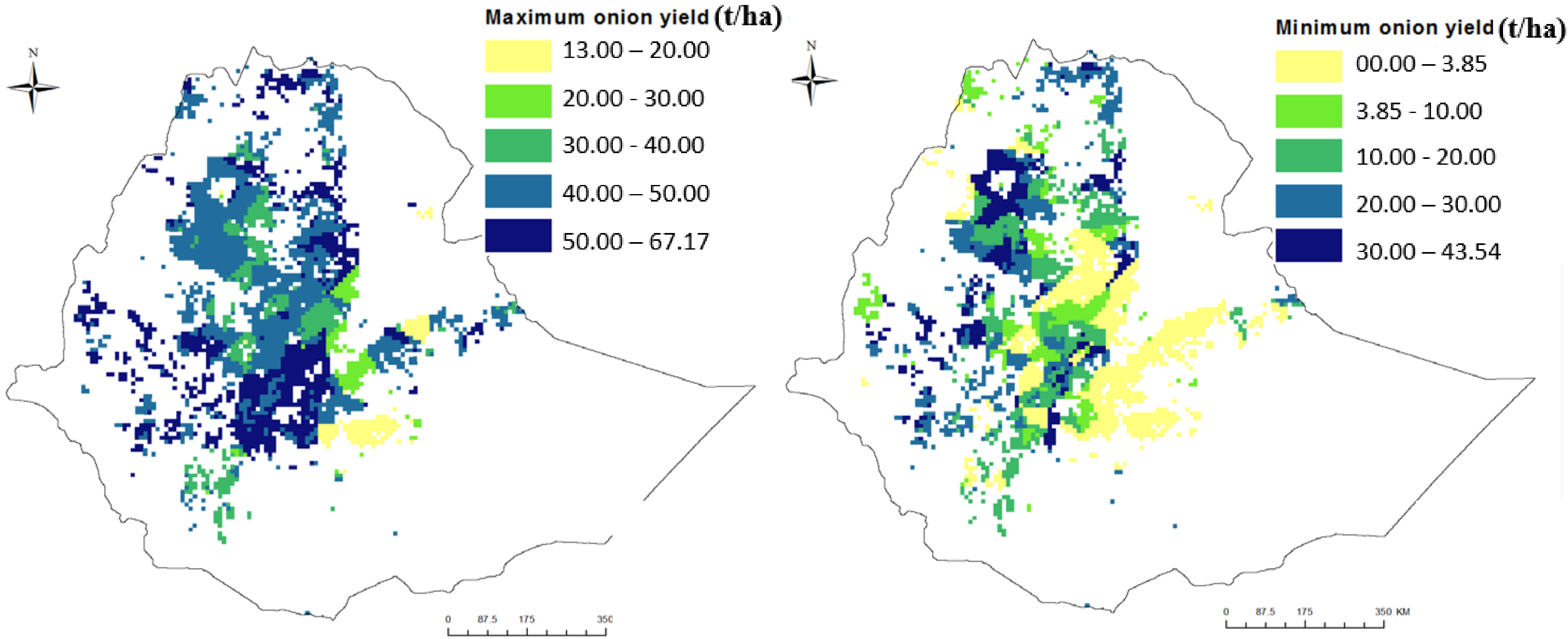
WATER RESOURCES POTENTIAL





- A significant amount of surface runoff and groundwater recharge available across the country to expand SSI.

POTENTIAL FOR VEGETABLE PRODUCTION



- A large part of the country, productive for producing vegetables and fodder during the dry season

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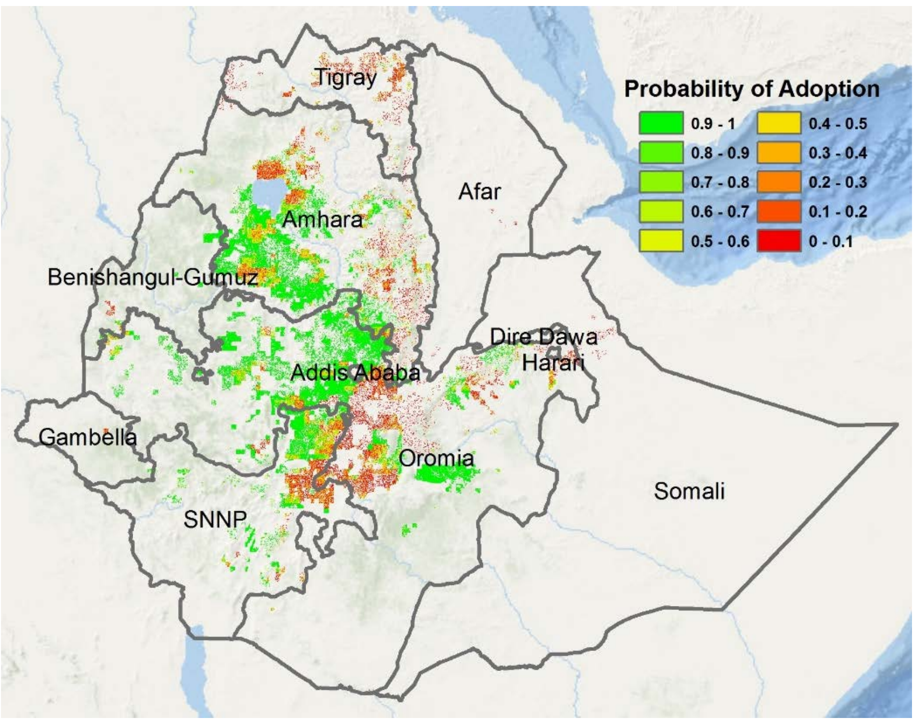
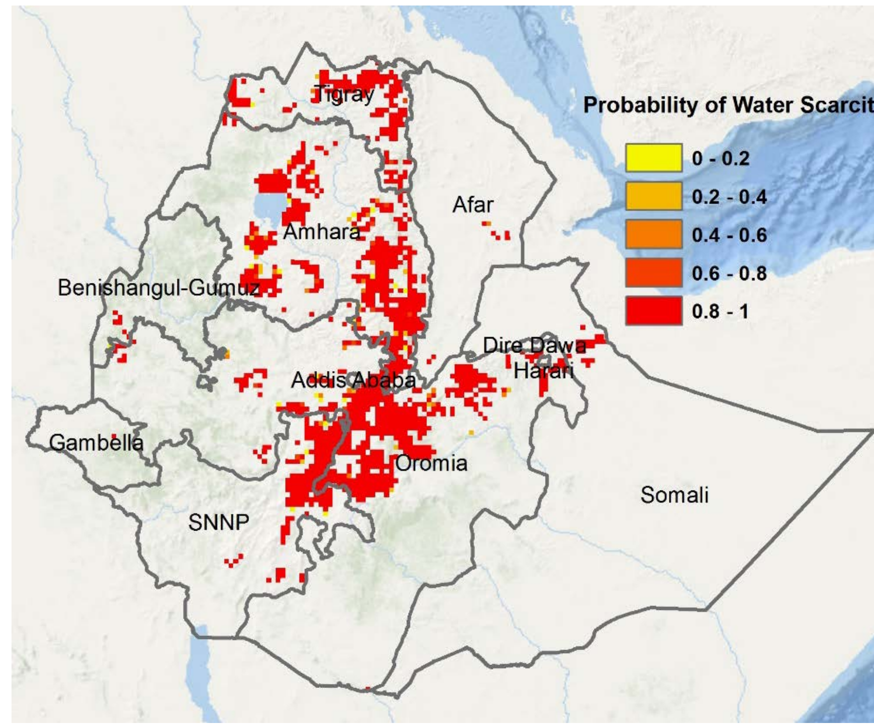
PROBABILITY OF IRRIGATION ADOPTION AND WATER SCARCITY





- High adoption probability for SSI at Lake Tana and Ethiopian Great Rift Valley areas
- SSI development may pose widespread water scarcity

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ESTIMATED SMALL-SCALE IRRIGATION ADOPTION POTENTIAL IN ETHIOPIA

	Vegetables & pulses (ha)	Fodder (ha)	Total (ha)	Profits (Million USD/yr)	Number of beneficiaries (Thousand People)
Addis Ababa	0	0	0	0	0
Affar	51	14	66	0.1	0.4
Amhara	314,394	141,047	455,440	1,066	2,581
Benishangul-Gumuz	15,861	259	16,120	37	91
Dire Dawa	0	51	51	0.08	0.3
Gambella	594	0	594	2.3	3
Harari	0	46	46	0.2	0.3
SNNP	77,602	40,569	118,171	399	670
Tigray	5,686	6,596	12,282	45	70
Oromiya	261,401	172,218	433,619	1,041	2,457
Somali	27	219	245	1	1
Total	**675,642**	**361,021**	**1,036,663**	**2,593**	**5,874**

- **~1 million ha** of land, **economically and biophysically** suitable for SSI development in Ethiopia,
- A net income of **~2.6 billion USD/year** from the SSI adoption,
- Amhara, Oromia and SNNPR having the highest SSI adoption potential.

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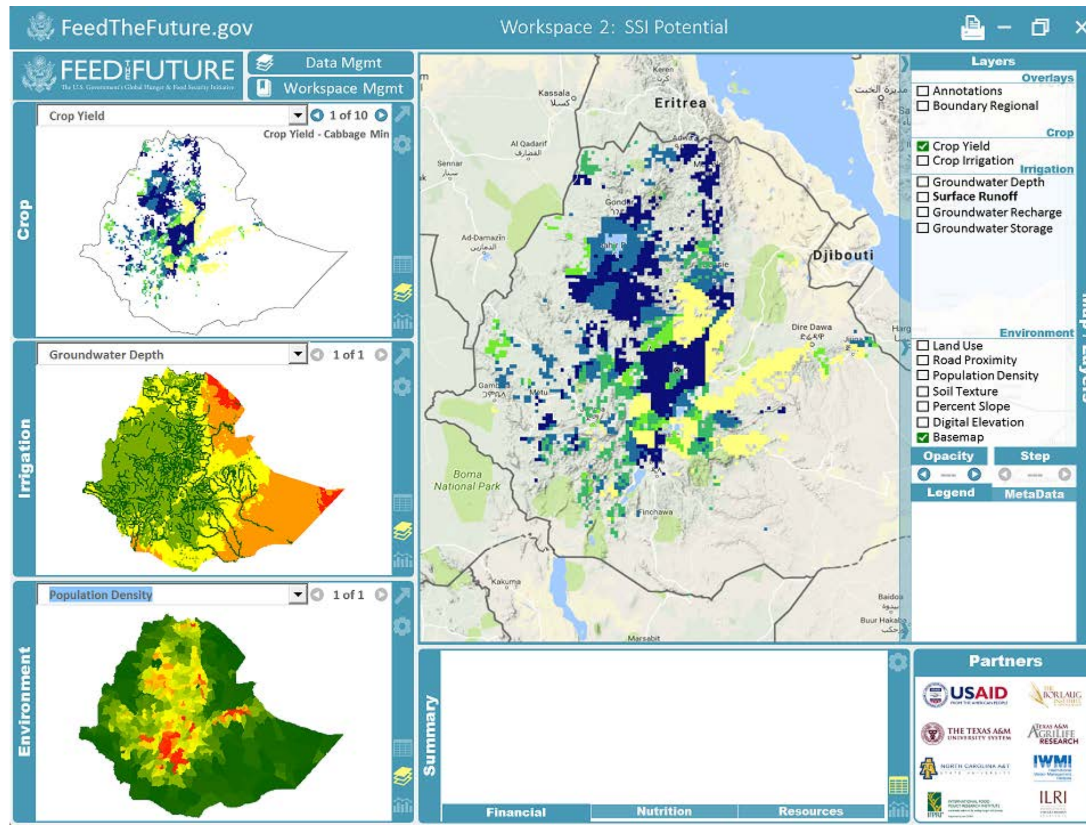
DEVELOPMENT OF DASHBOARD TO HARNESS THE POWER OF IDSS

- 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-day) – 327M + 41F = 368
- Extended training for experts from project countries (90-day)
- Graduate professional training in U.S. institutions (2-3 years)
- Institutionalization of IDSS (long term

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, and
  - Ethiopian Agricultural Transformation Agency (ATA) tailored IDSS training for irrigation planning

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

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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

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
  - Solar pumps – economical and workable
  - Labor – a major limitation on using low cost technology
- Minimal to modest environmental impacts due to adoption of SSI
- Substantial potential for scaling SSI nationally, e.g. more than **4.5 million people** could benefit generating more than **250 million USD/year** using SSI in Ethiopia
- Key personnel trained with IDSS application, and IDSS institutionalized to educate the next generation scientists and professionals to scale up SSI

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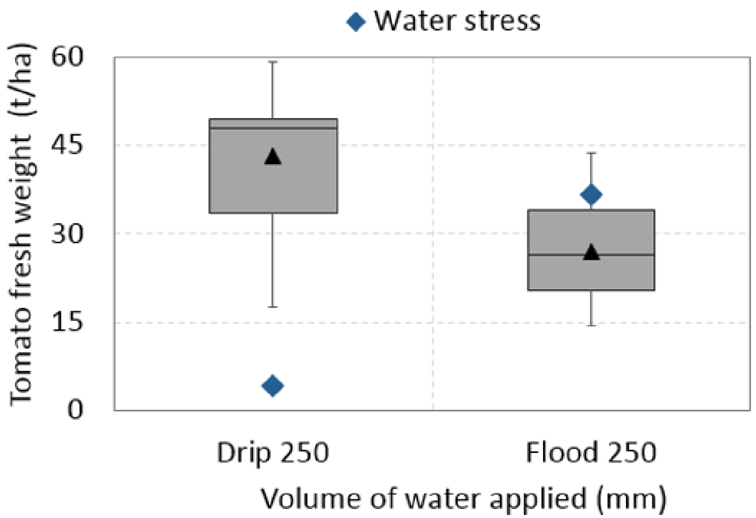
TESTING IRRIGATION APPLICATION OPTIONS

Crop yield and water stress days of drip and flood irrigation



- Drip irrigation improves crop water productivity, and reduces water loss.

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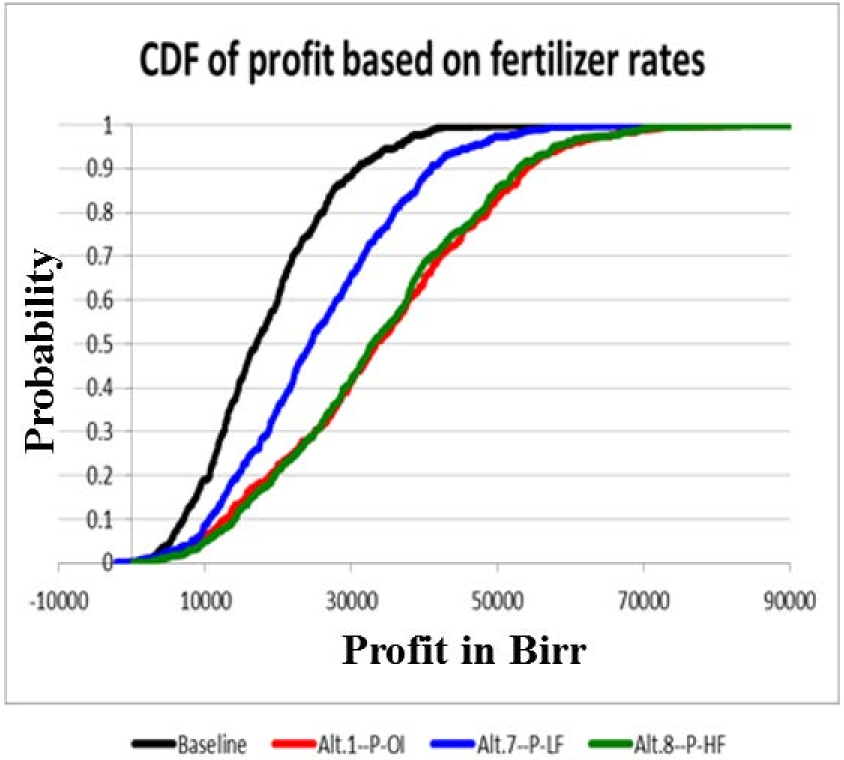
GAP AND CONSTRAINT ANALYSIS: FERTILIZER TECHNOLOGY



- Description of the fertilizer scenarios:
  - **Baseline**: current fertilizer rates
  - **Alt. 1**: application of optimal fertilizer rates (Urea-DAP): 240-100 kg/ha
  - **Alt. 7**: application of 50-120 kg/ha (lower than optimal)
  - **Alt. 8**: application of 300-100 kg/ha (higher than optimal)
- All the 3 alternative scenarios are profitable compared to the baseline.

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PLANNING AND EVALUATION OF SMALL SCALE IRRIGATION AT NATIONAL SCALE

Farms to Nations using models

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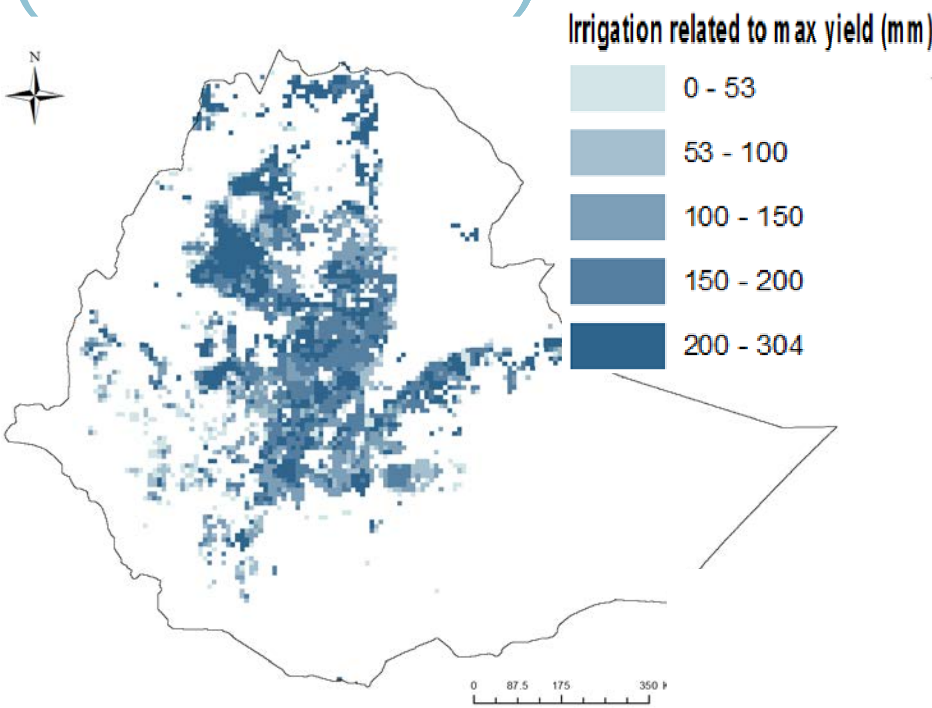
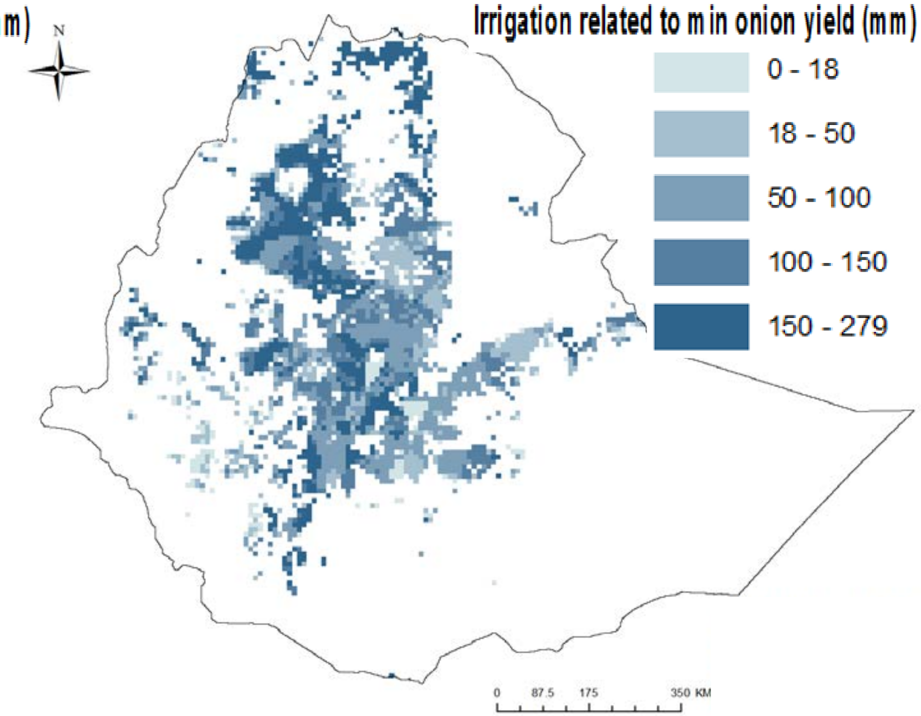
IRRIGATION FOR DRY SEASON CROPPING (E.G. ONION)





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

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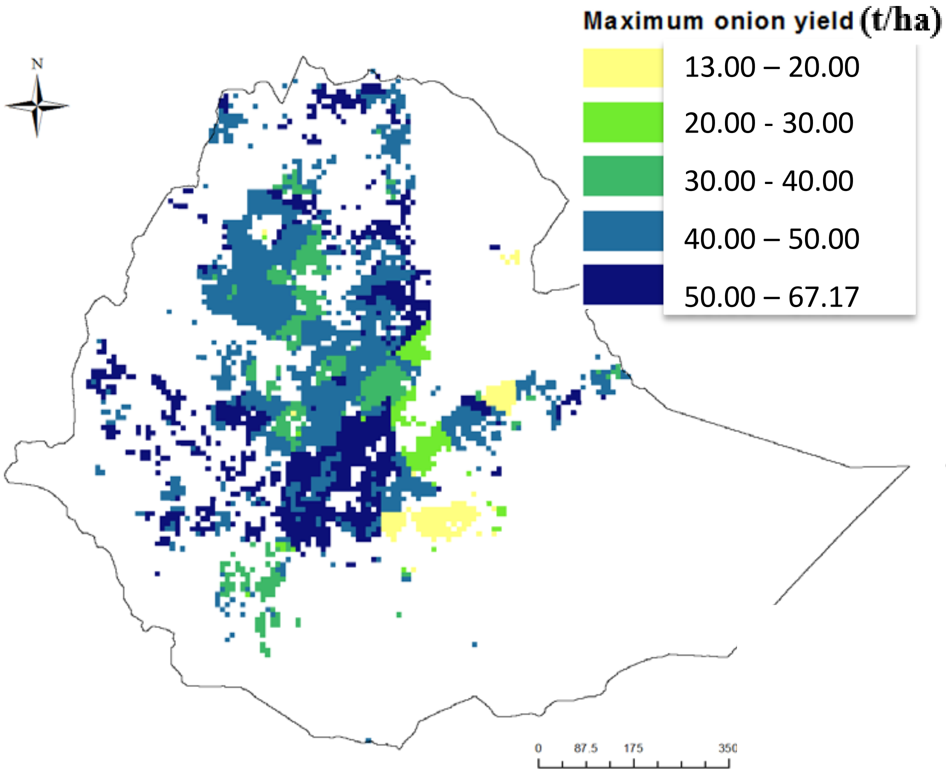
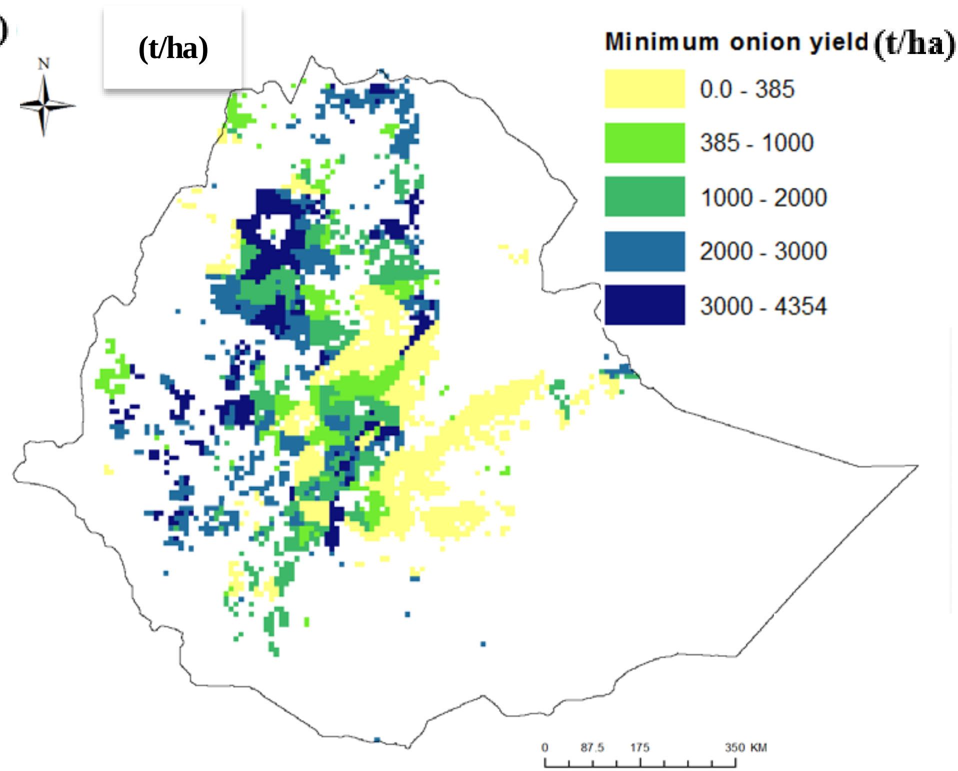
POTENTIAL FOR VEGETABLE PRODUCTION





- A large part of the country, productive for producing vegetables and fodder during the dry season

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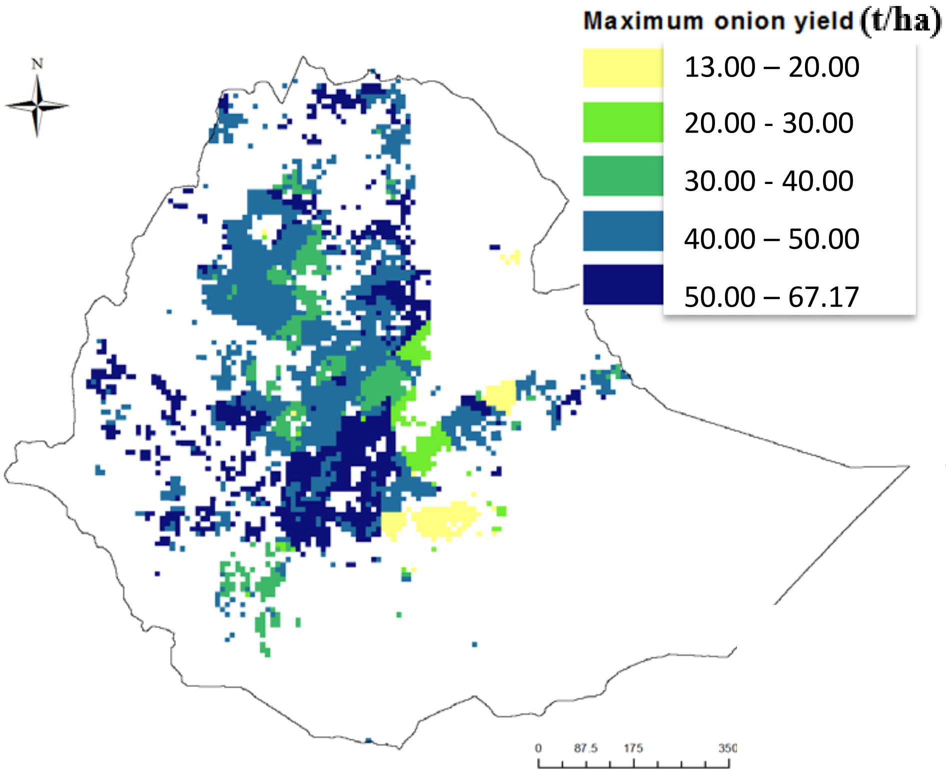
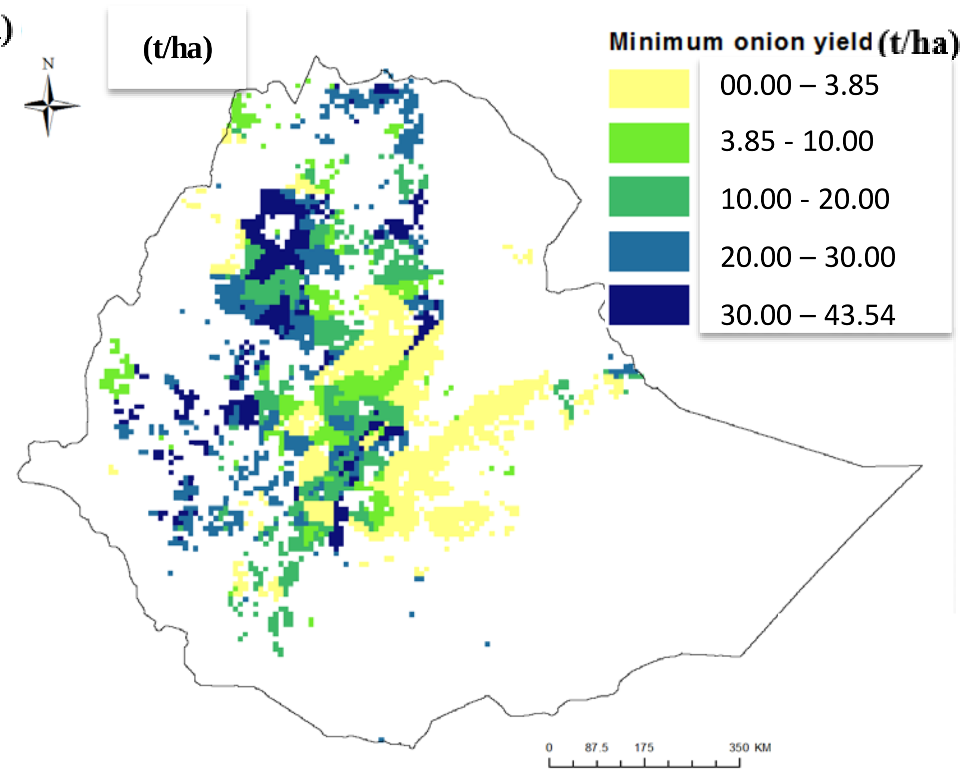
POTENTIAL FOR VEGETABLE PRODUCTION





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INSTITUTIONALIZING IDSS

- **Universities** included IDSS models in their curricula to train the next generation scientists and professionals, e.g.
  - Addis Ababa University and Bahir Dar University, Ethiopia
  - Sokoine University of Agriculture, University of Dar es Salaam, and Nelson Mandela African Institute of Science and Technology, Tanzania

- **Government Institutions** are interested to use IDSS for planning and evaluation of government initiatives, e.g.
  - Ethiopian Agricultural Transformation Agency (ATA),
  - Abay (Blue Nile) Basin Authority – Ethiopia,

- **CGIAR centers, NGOs and Private sector** for environmental analysis and engineering design
  - CIAT, IWMI, Ethiopian Construction Works Design and Supervision Enterprise (ECWDSE) and various private agencies