PIRE: Water and Food Security in Ethiopia

An Interdisciplinary Approach to Improve Human Security in a Water-Dependent Emerging Region

Project Aim

Understand how the relationships between scientists, farmers, water managers, and other authorities influence the production, dissemination, and outcome of new scientific knowledge

Kudmi field site, 2017 (Ezana)

Dual Objectives

Improve seasonal hydrologic and crop yield forecasts at scales relevant to farmers and water managers; and

test a political-institutional model of science that challenges the assumption that innovation leads automatically to improved human security.

Project Aim

Understand how the relationships between scientists, farmers, water managers, and other authorities influence the production, dissemination, and outcome of new scientific knowledge

EIWR students discussing water sanitation solutions with communities.

Expected Outcomes

- Enhance crop and energy production in normal years and minimized losses during climatic extremes;
- Identify and reduce socio-political barriers to effective forecast development, dissemination and uptake;
- train a new generation of global experts who recognize the political-institutional and climate-ecological dimensions of complex food-energy-water problems.

Project Implementation

In situ stakeholder and citizen science data transmitted through the e-ping app

Fall 2018

1) Developed the forecasting system
2) Trained ABM based on input from survey data
3) Prepared for the ethnographic visits

Spring 2019

Summer 2019

Undergrad and Graduate Student Field Visits

Citizen Science Sensor Deployment

2020

2021

Stakeholder/policy outreach workshop

Summer School

Working on Inter-disciplinary Research Investigations
testing hypotheses

Run the forecasting system: Issued seasonal crop yield and hydrologic forecasts and the bulletins for the wet and dry seasons in May 2019, and September 2019, respectively. Will repeat in 2020 and 2021.

Ethnographic field work (EFW): Did the first field work from February - October 2019. Will repeat with two-month visits in 2020 and 2021.
- Collected survey data in March-April 2019

Project Accomplishments

- Developed the integrated forecasting system
- Completed the first year of ethnographic investigations and completed the surveys
- Completed 2+ years of citizen science data collection
- Published 5 journal papers, with more papers in preparation. Also, presented 21 conference papers
- Involved 14 graduate students and 10 undergraduate students in the process
  - From the 14 grad students, 12 are funded from NSF PIRE
  - The list includes 4 Female Grad Students
  - 8 International Students, of which 3 Students from Ethiopia
- Developed and offered our first Water Energy and Food Nexus course

PIRE Water and Food Security Project

Q&A

Impact of Seasonal Climate Forecasting: Modelling Update

Liangzhi You, Jonathan Lala, Paul Block, Ying Zhang

PIRE 3rd Annual Meeting

November 20-21, 2019

UConn, Storrs, Connecticut, USA

Economic value of climate forecasting

Vol. 33: 67–79, 2006 | CLIMATE RESEARCH
Clim Res | Published December 21

Ex post assessment methods of climate forecast impacts

Siwa Msangi, Mark W. Rosegrant*, Liangzhi You

International Food Policy Research Institute, 2033 K Street NW, Washington, DC 20006, USA

ABSTRACT: While a considerable body of literature has grown around the ex ante assessment of the value of climate forecast information, relatively little has been applied to ex post analyses. Using the literature that assesses the impact of agricultural research and extension as a starting point, our paper suggests advancements in survey design, data collection, econometric methodology and project evaluation that can improve ex post impact assessment of climate forecast information. We also emphasize the need to better integrate economic theory with empirical methodology, so as to account for behavioral dynamics and the presence of rigidities and fixities facing economic agents and food production systems. Through these types of advances in theoretical and empirical modeling, researchers will be better equipped to conduct ex post impact assessment and more accurately measure the value of the climate forecast information reaching the agricultural producer.

KEY WORDS: Economic valuation · Econometric methods · Ex post assessment · Climate forecast

Economic value of climate forecasting – Modelling approach

AGRICULTURAL ECONOMICS

Agricultural Economics 39 (2008) 171–181

Impacts of considering climate variability on investment decisions in Ethiopia

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[b] *University of Colorado at Boulder, 428 UCB, Boulder, CO 80309-0428, USA*
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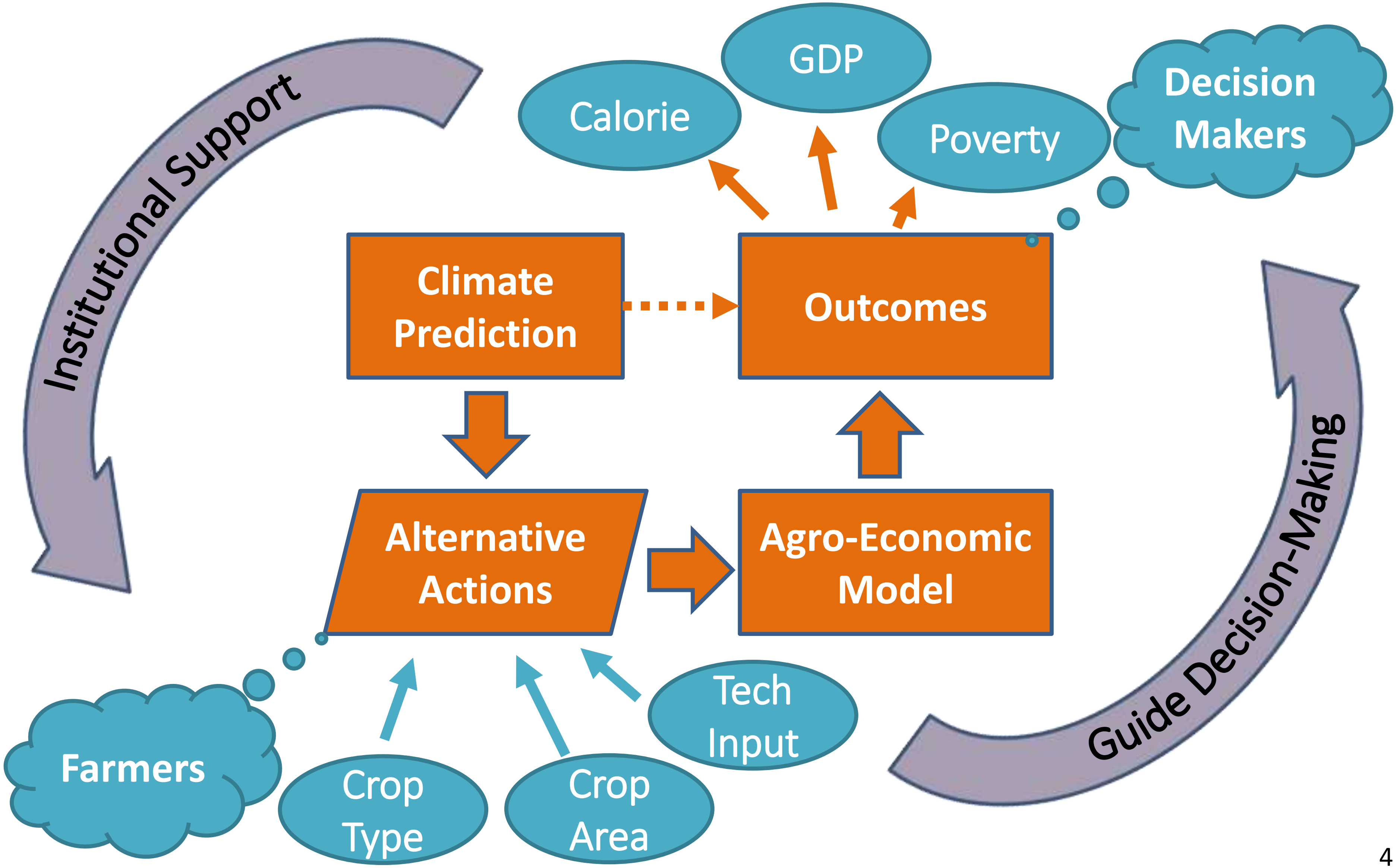
Abstract

Extreme interannual variability of precipitation within Ethiopia is not uncommon, inducing droughts or floods and often creating serious repercussions on agricultural and nonagricultural commodities. A dynamic climate module is integrated into an economy-wide model containing a detailed zonal level agricultural structure. This coupled climate-economic model is used to evaluate the effects of climate variability on prospective irrigation and infrastructure investment strategies, and the ensuing country-wide economy. The linkages between the dynamic climate module and the economic model are created by the introduction of a climate-yield factor (CYF), defined at the crop level and varied across Ethiopian zones.

Economic value of climate forecasting - PIRE Approach



Ethiopian multi-market model

- Originally developed by IFPRI, further improved by Paul Block
- 3 sectors – detailed agriculture
- zonal level
- include imports and exports
- supply = demand (equilibrium)
- crop-yield factors (CYF) represent influence of water availability on yields (0~1)

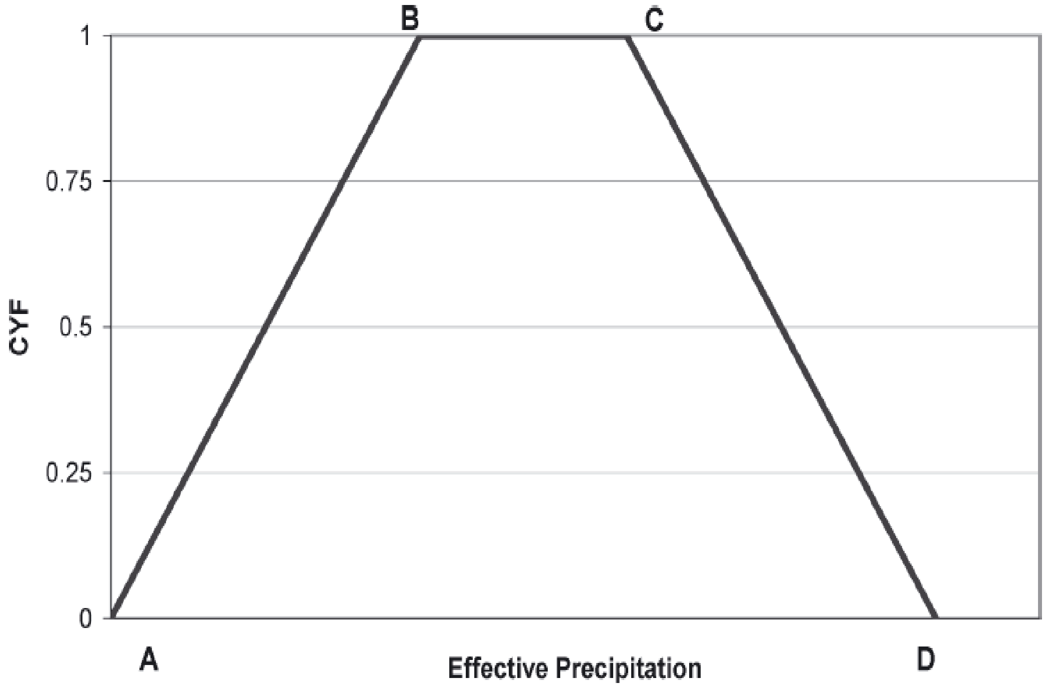


Fig. 1. Generic relationship between CYF and effective precipitation.

Sources: Block et al. 2008

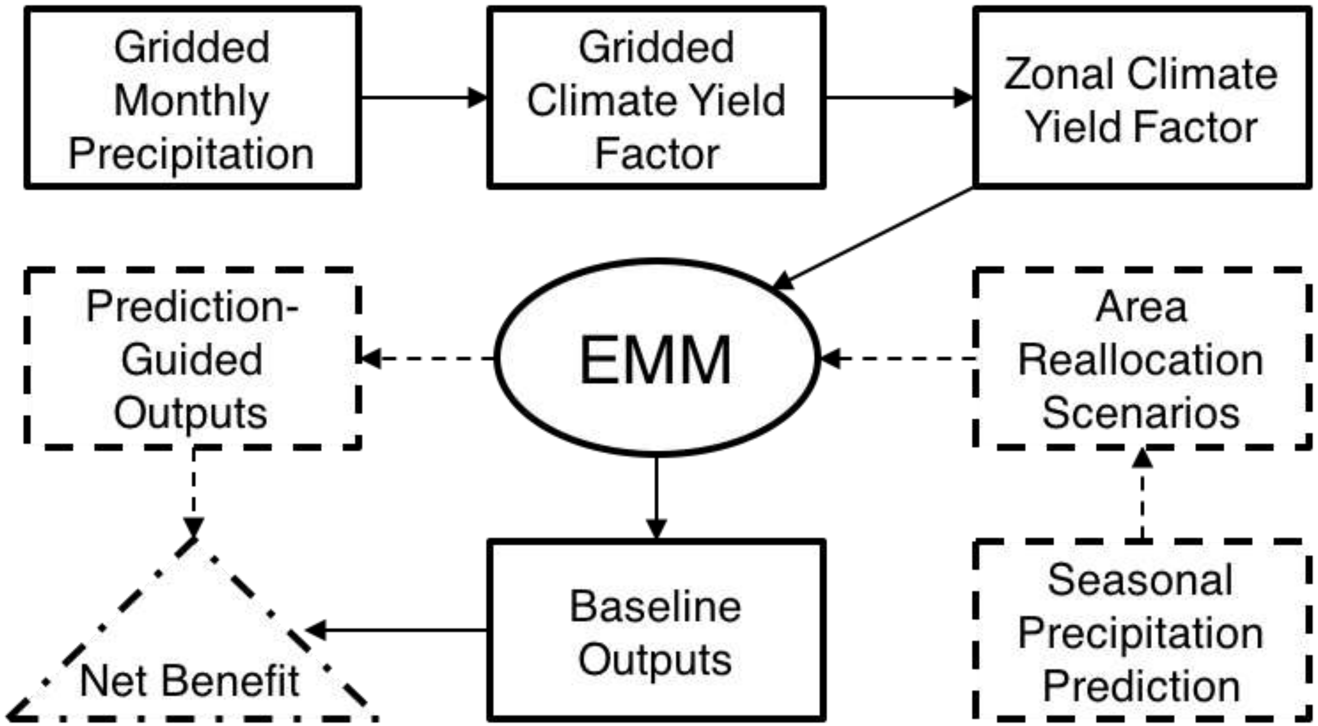
Agricultural commodities included in the model

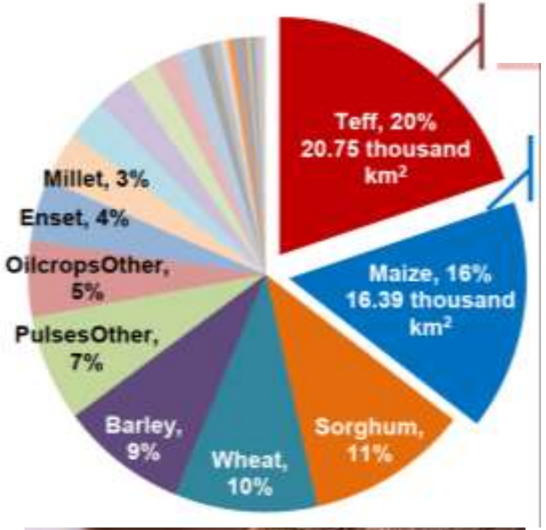
Maize, teff, wheat, sorghum, barley, millet, oats, rice,
Potatoes, sweet potatoes, Enset, other root crops,
Beans, peas, other pulses,
Groundnuts, rapeseed, sesame, other oil crops,
Domestic vegetables, bananas, other domestic fruits,
Exportable vegetables, other horticultural crops, chat, cotton,
Coffee,
Sugar, beverages and spices,
Bovine meat, goat meat and mutton, other meat,
Milk and dairy products,
Poultry and eggs, fish.

Modelling Approach

use prediction to reallocate agricultural land choices

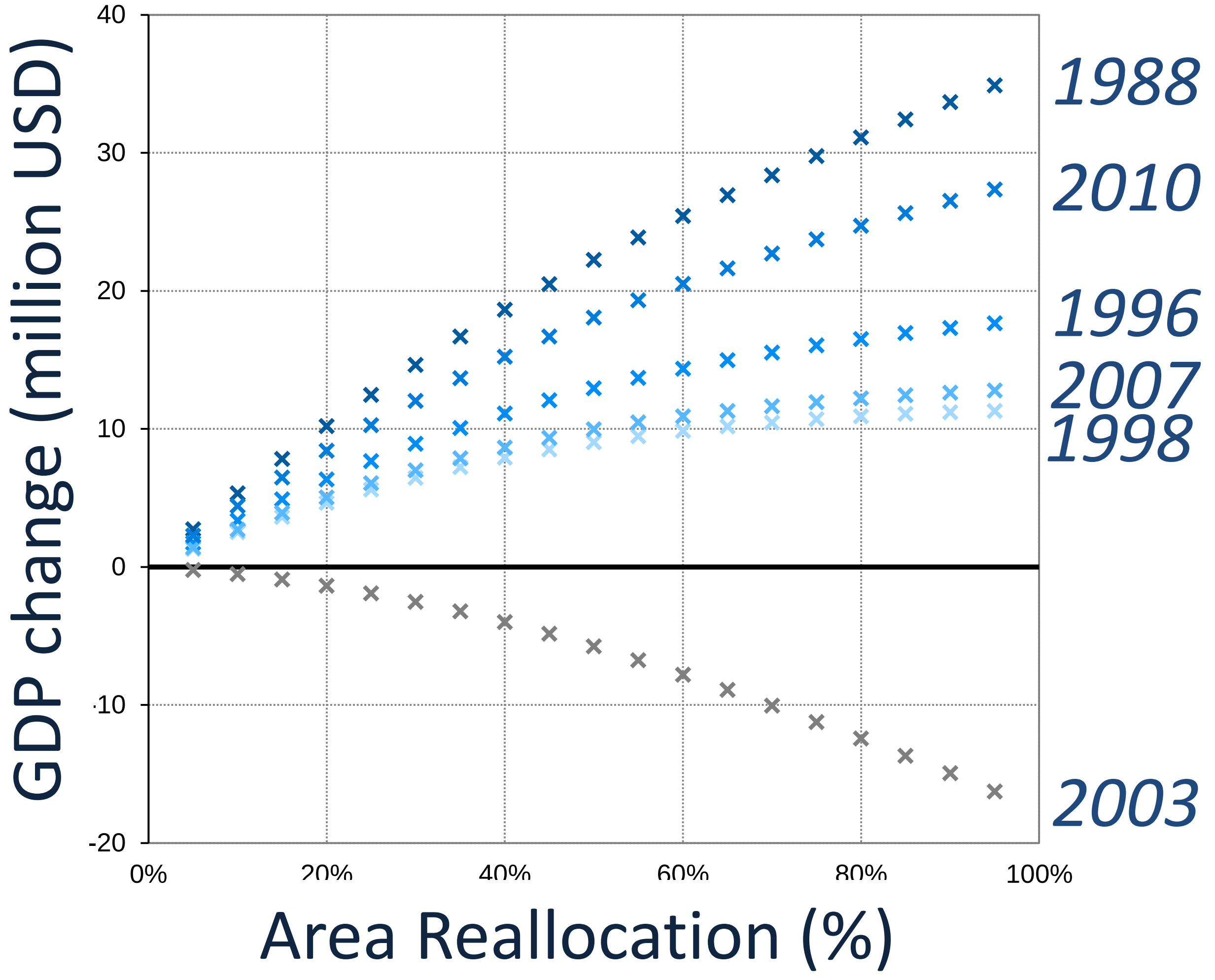
Maize (high CWR; high value) ⟷ Teff (low CWR; low value)





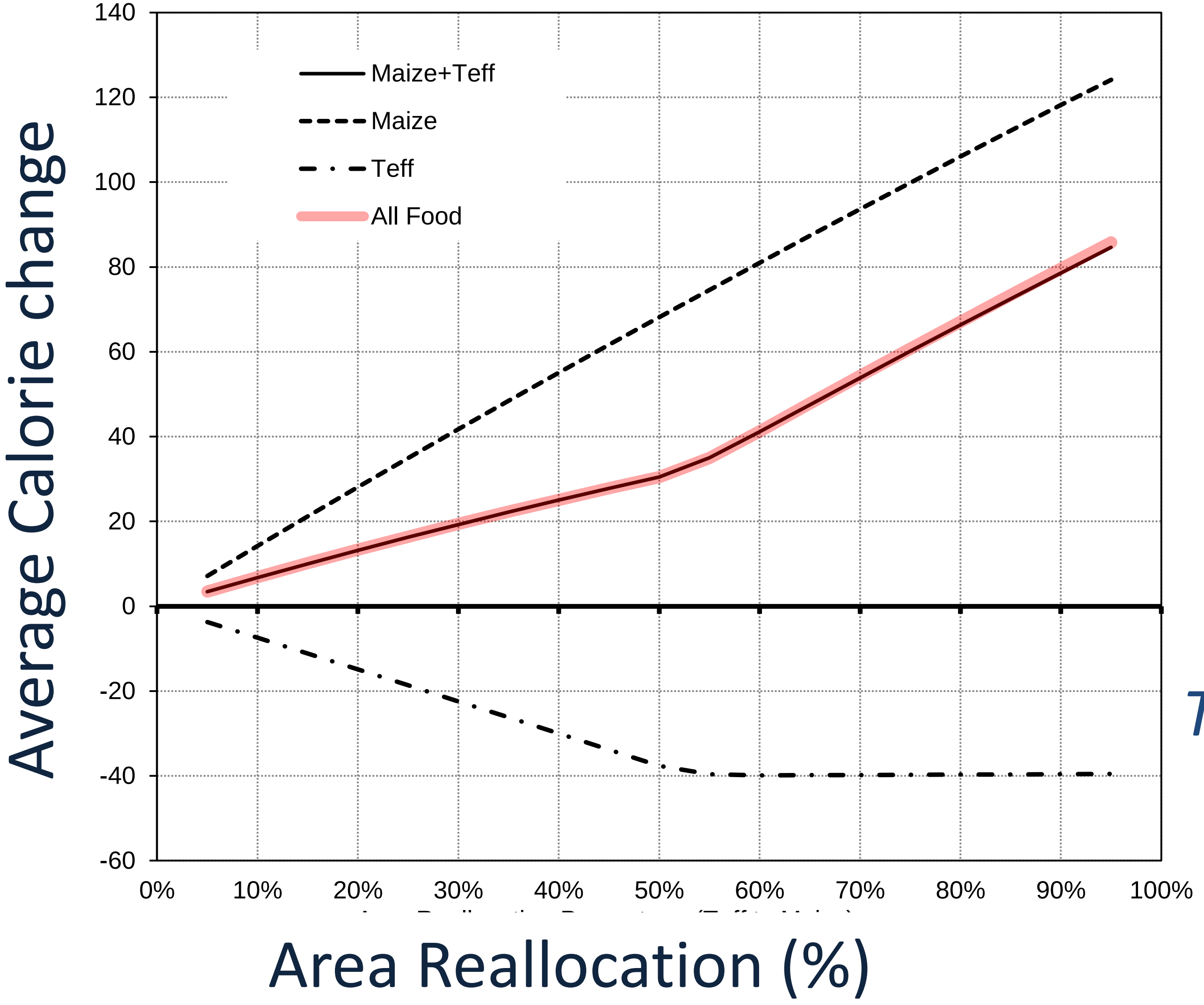
Benefit of Correct Forecasting

reallocate teff to maize only when **above normal** predicted



Average Calorie Change – Price Effect

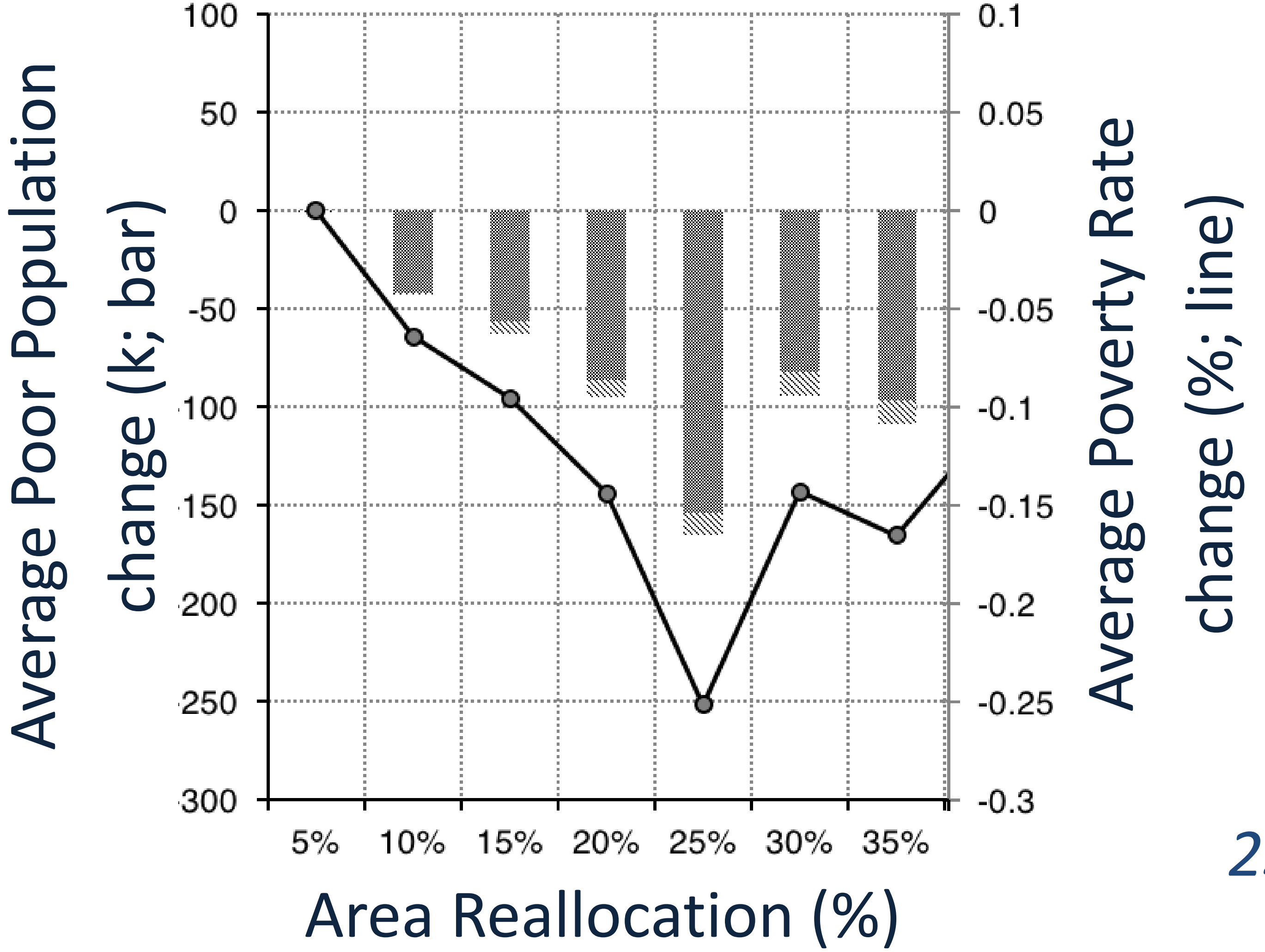
reallocate teff to maize only when **above normal** predicted



Teff imported

Poverty Reduction

reallocate teff to maize only when **above normal** predicted



25% best

Economic value of climate forecasting – A paper just accepted

Climatic Change

Integrating Climate Prediction and Regionalization into an Agro-economic Model to Guide Agricultural Planning

--Manuscript Draft--

Manuscript Number:	CLIM-D-18-00692R2
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Article Type:	Research Article
Corresponding Author:	Ying Zhang Johns Hopkins University UNITED STATES
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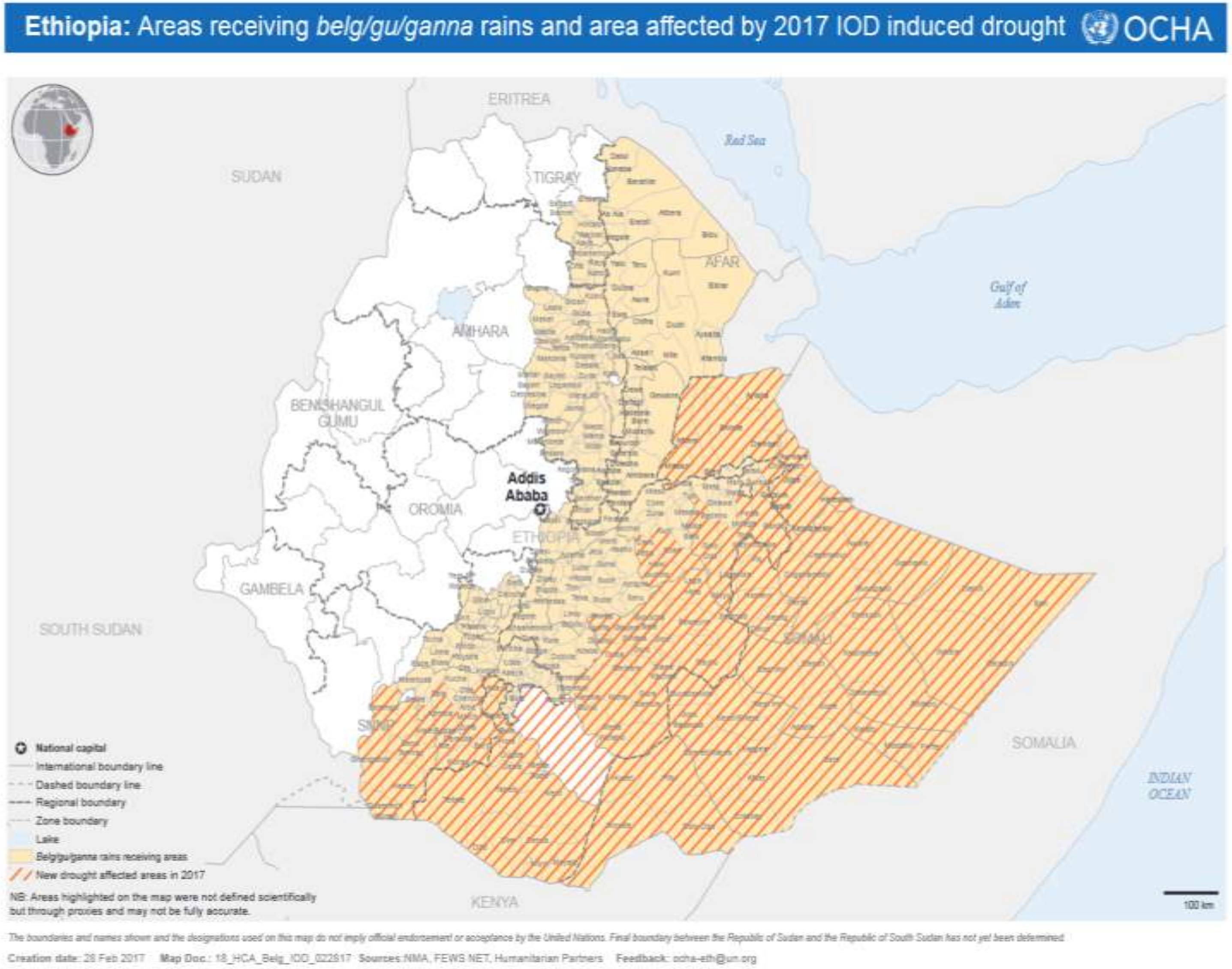
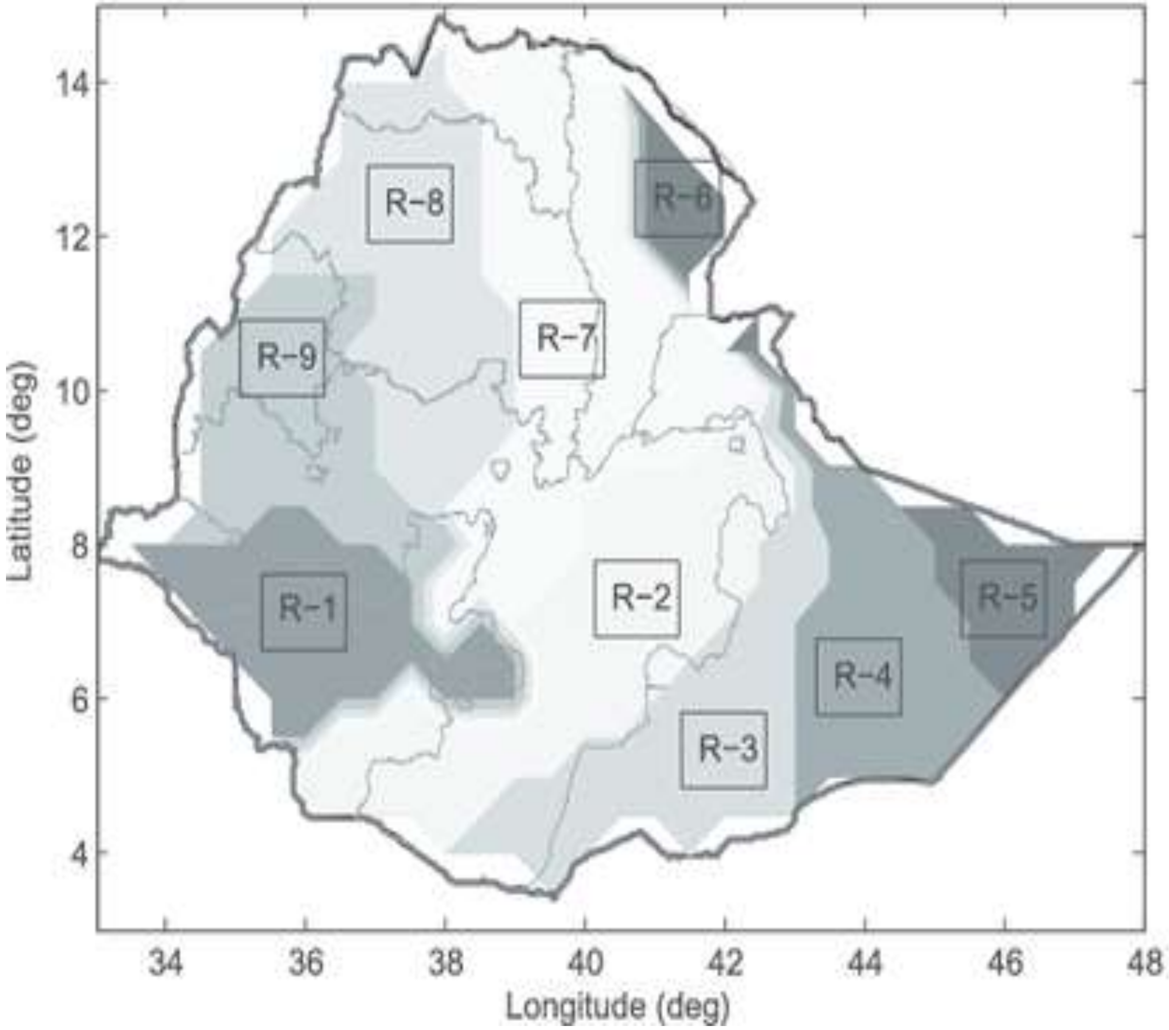
Corresponding Author's Institution:	Johns Hopkins University
Corresponding Author's Secondary Institution:	
First Author:	Ying Zhang
First Author Secondary Information:	
Order of Authors:	Ying Zhang
	Liangzhi You
	Donghoon Lee
	Paul Block

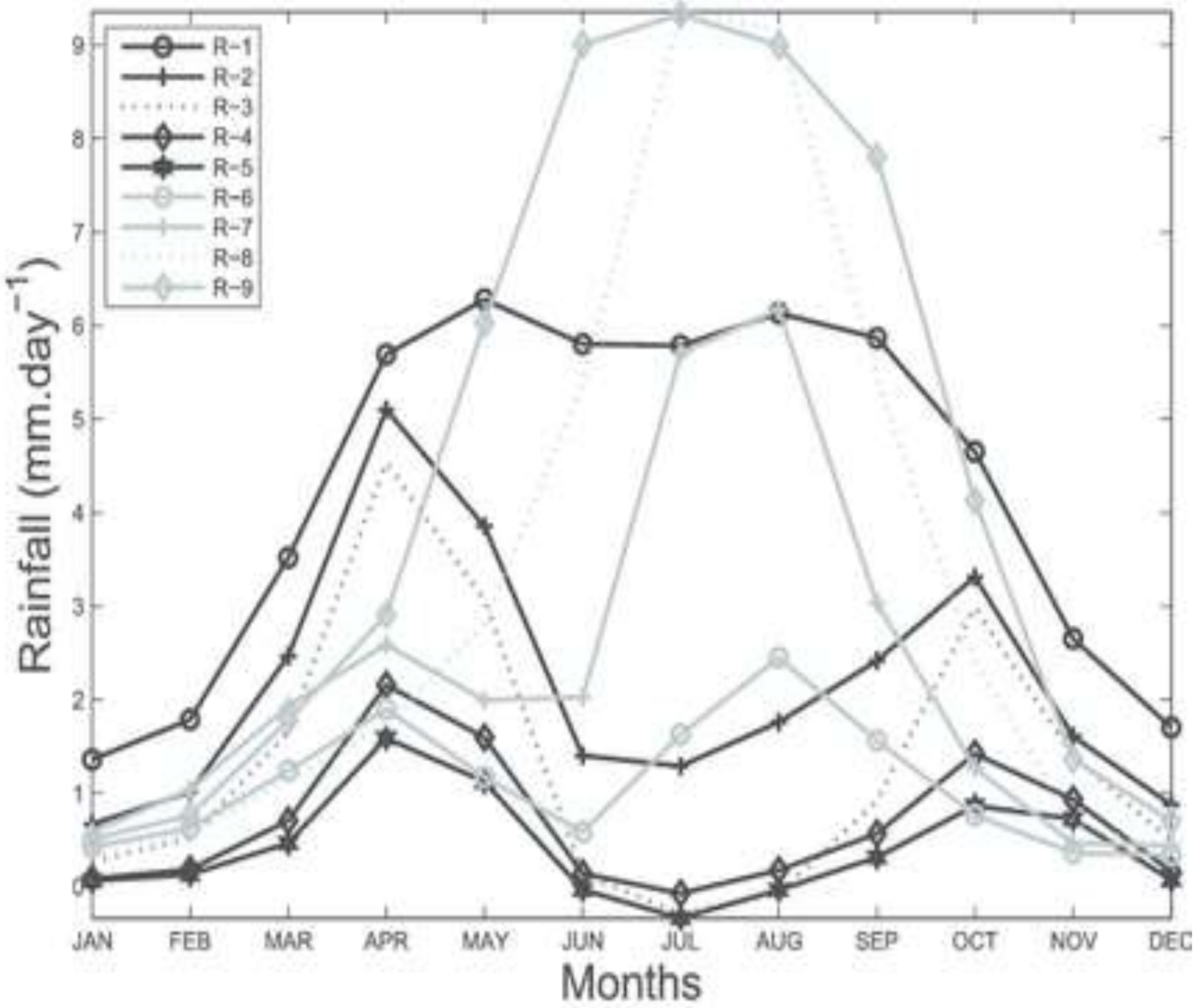
Model Update 1

Update with recent data: baseline year from 2003(!!) to 2015-17, Ethiopia zones increases and changes



Model Update 2: Incorporating Seasonality





Model Update 3: Change technology inputs


Food Policy 48 (2014) 168–181

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journal homepage: www.elsevier.com/locate/foodpol

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FOOD POLICY

Mechanization in Ghana: Emerging demand, and the search for alternative supply models

CrossMark

http://crossmark.crossref.org/dial ol.2014.05.013&domain=pdf

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ABSTRACT

Influential studies in the 1980s and early 1990s drew on the Boserup–Ruthenberg theories of farming systems evolution to argue that African countries were not yet ready for widespread agricultural mechanization. Through applying the theories of farming systems evolution and of induced innovation in technical change, this paper shows that demand for certain mechanized farming operations

Original four technology inputs (fertilizer, improved seed, pesticide, irrigation). Now mechanization is critical in Ethiopia.

Summary

- **Climate variability** has large impact on the economy in Ethiopia
- Seasonal climate forecasting has impact on farmers' decision making and livelihood. Evaluation of prediction generates **positive net benefits** in general, and yet have huge heterogeneity.
- The study **evaluates predictive information** using economic indices **at country level** based on possible actions given the prediction, which can serve as a foundation for policy intervention, decision making, and strategic planning.

- We will have more realistic scenarios after Sociological Experiments and Surveys and ABM modelling results

- The new model will not only be used in PIRE but also in IFPRI's Ethiopia Strategy Support Program in their analysis, e.g. the impact of irrigation expansion (strong push from government)

WATER AND FOOD SECURITY:

Development of agent-based model to improve communication of seasonal weather forecast in Ethiopia

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Sardorbek Musayev

Environmental Engineering Program
Department of Civil and Environmental Engineering
University of Connecticut

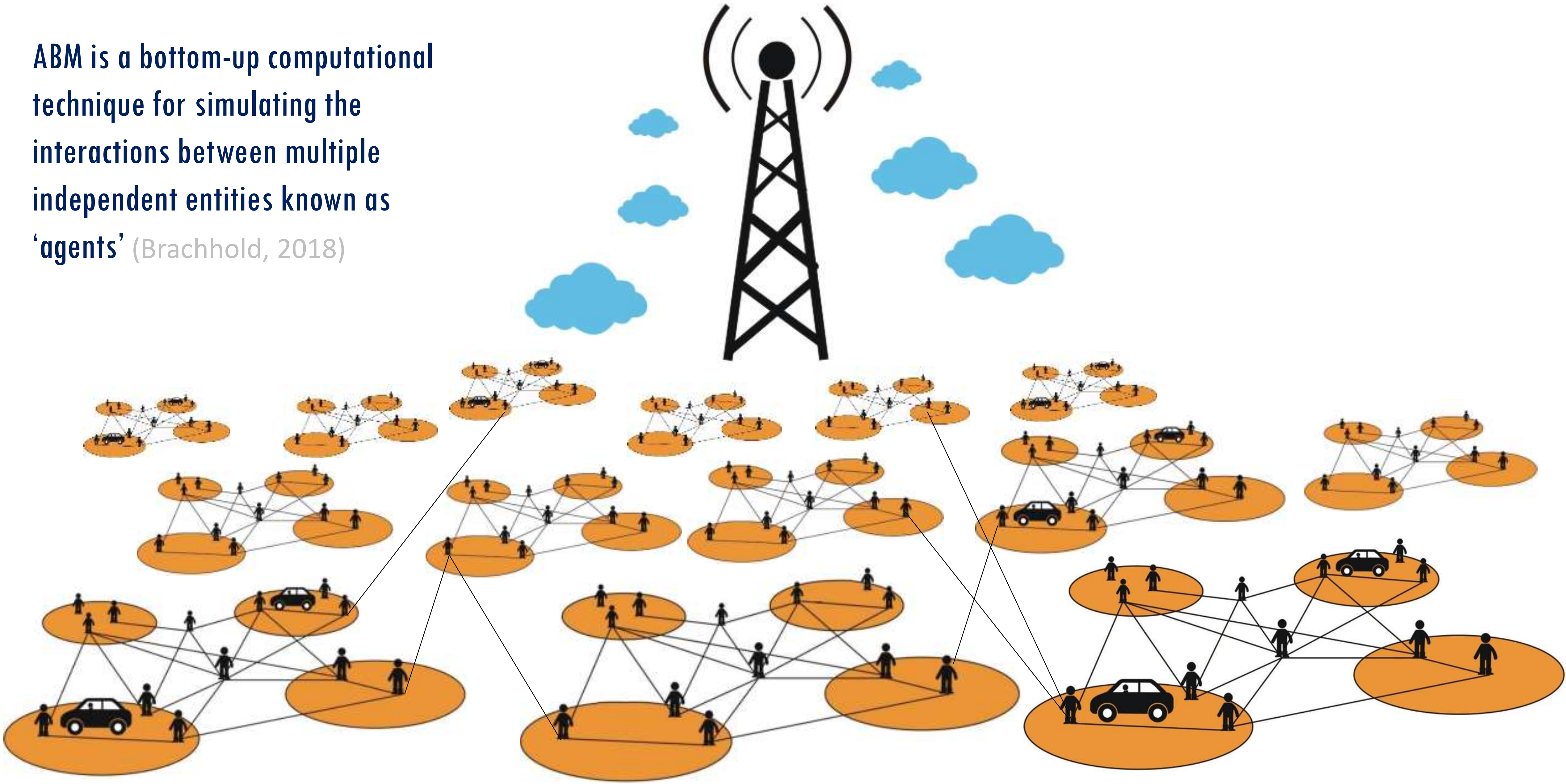
11/21/2019

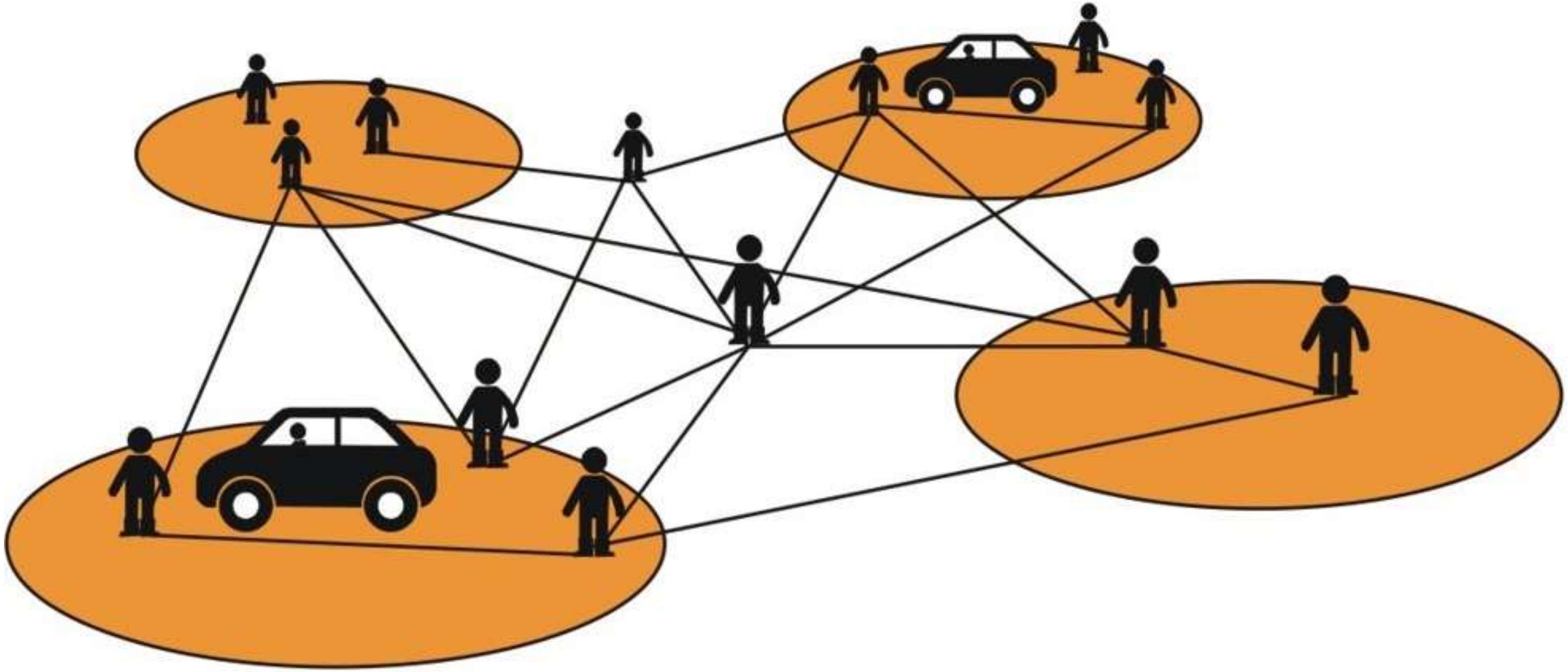
Objectives

- Identify the key information exchange agents
- Gain an understanding of the key information flow pathways by which the forecast might be disseminated and shared.
- Rank the relative importance of the different pathways and identify barriers to forecast adoption and explore ways to optimize forecast adoption.

What is Agent-Based Modeling (ABM)?

ABM is a bottom-up computational technique for simulating the interactions between multiple independent entities known as 'agents' (Brachhold, 2018)





Concept of forecast knowledge

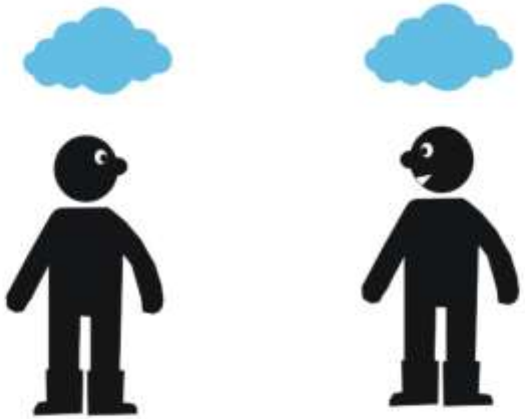
“Knowledge” is the technical unit term to rate agent’s status in the range of 0-100 knowledge unit.

It is a basic measuring unit to evaluate an agent that he/she has certain amount of weather forecast information

Knowledge sharing

Knowledge sharing

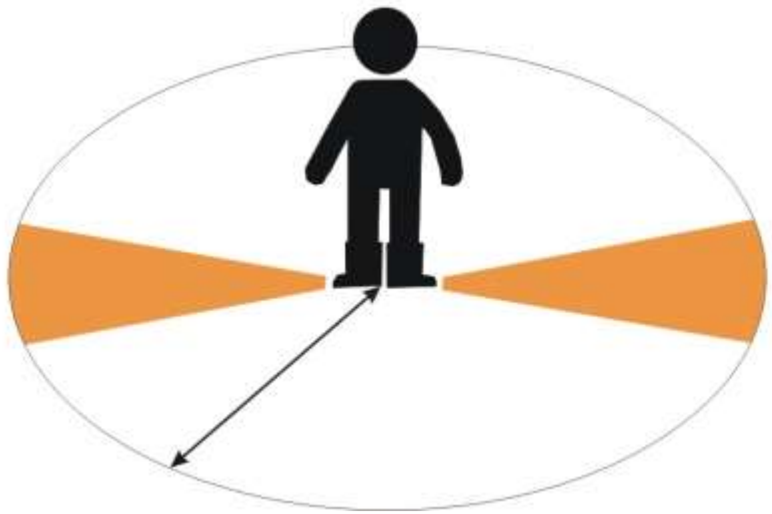
Knowledge sharing



Concept of farmer's vision for neighbors

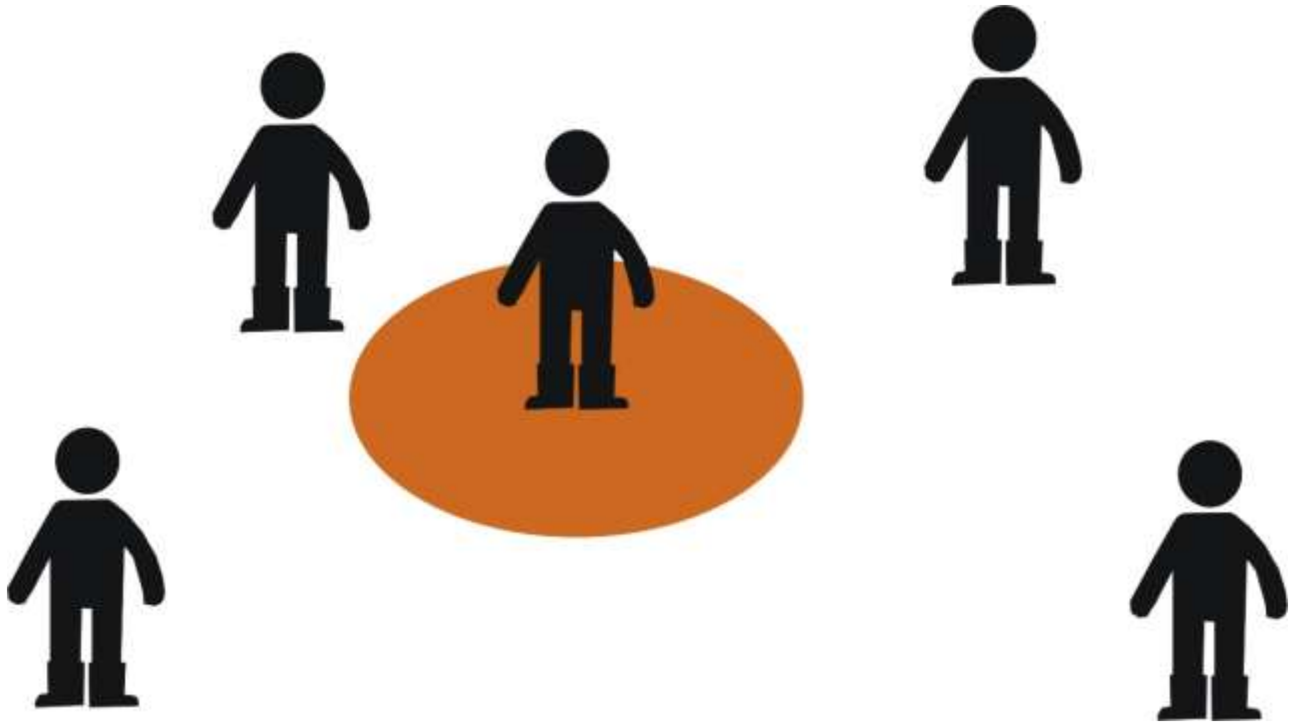
Concept of vision for neighbors

Concept of vision for neighbors



Concept of vision for neighbors

Concept of vision for neighbors



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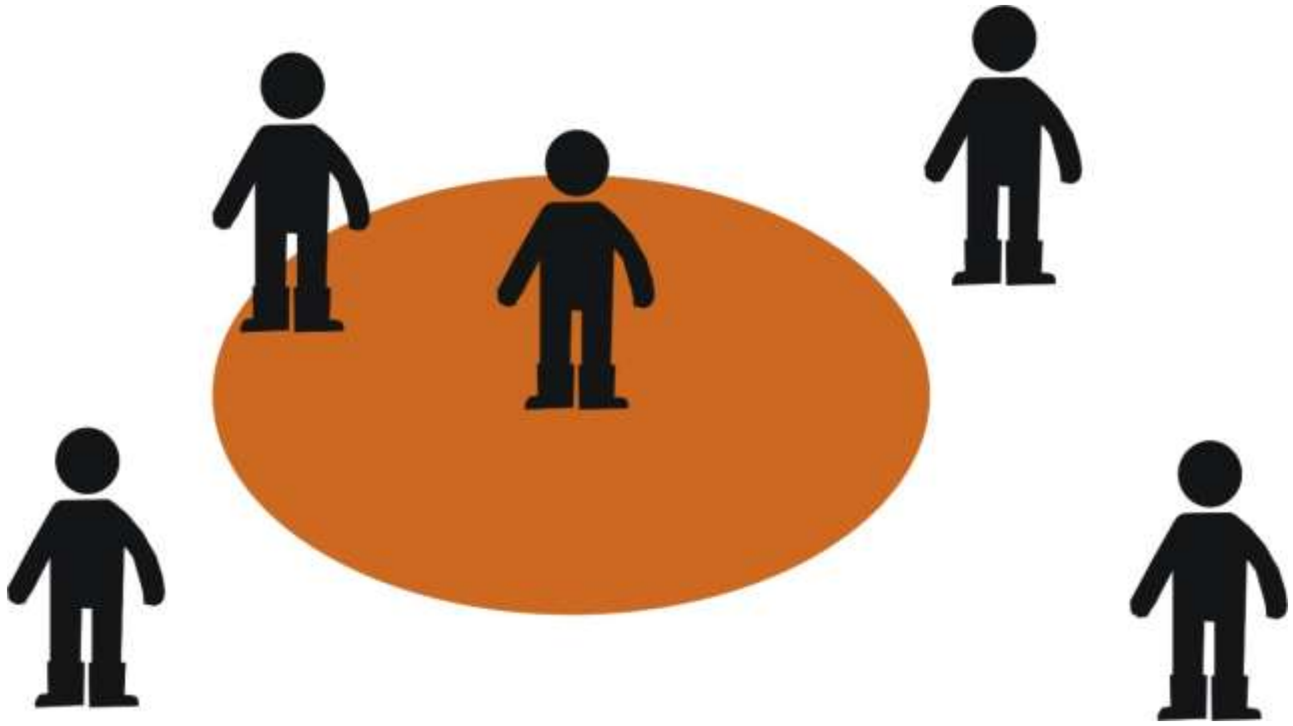

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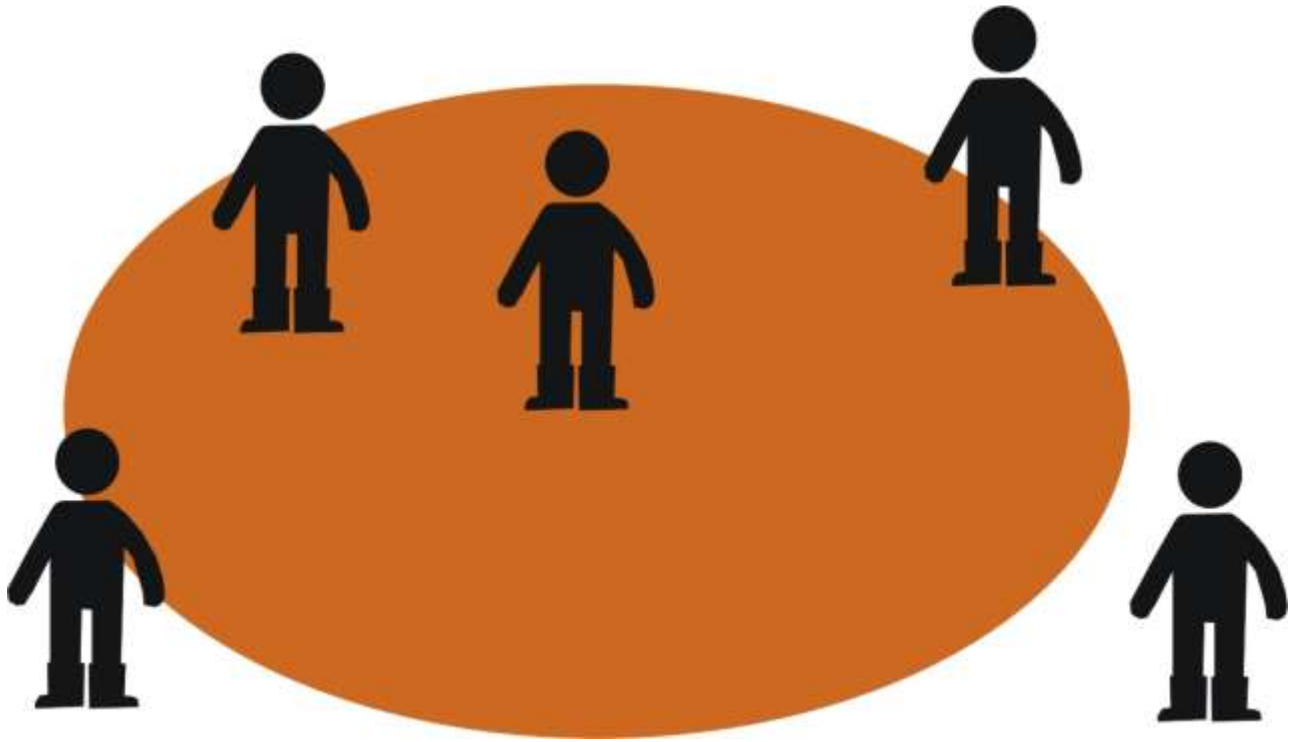

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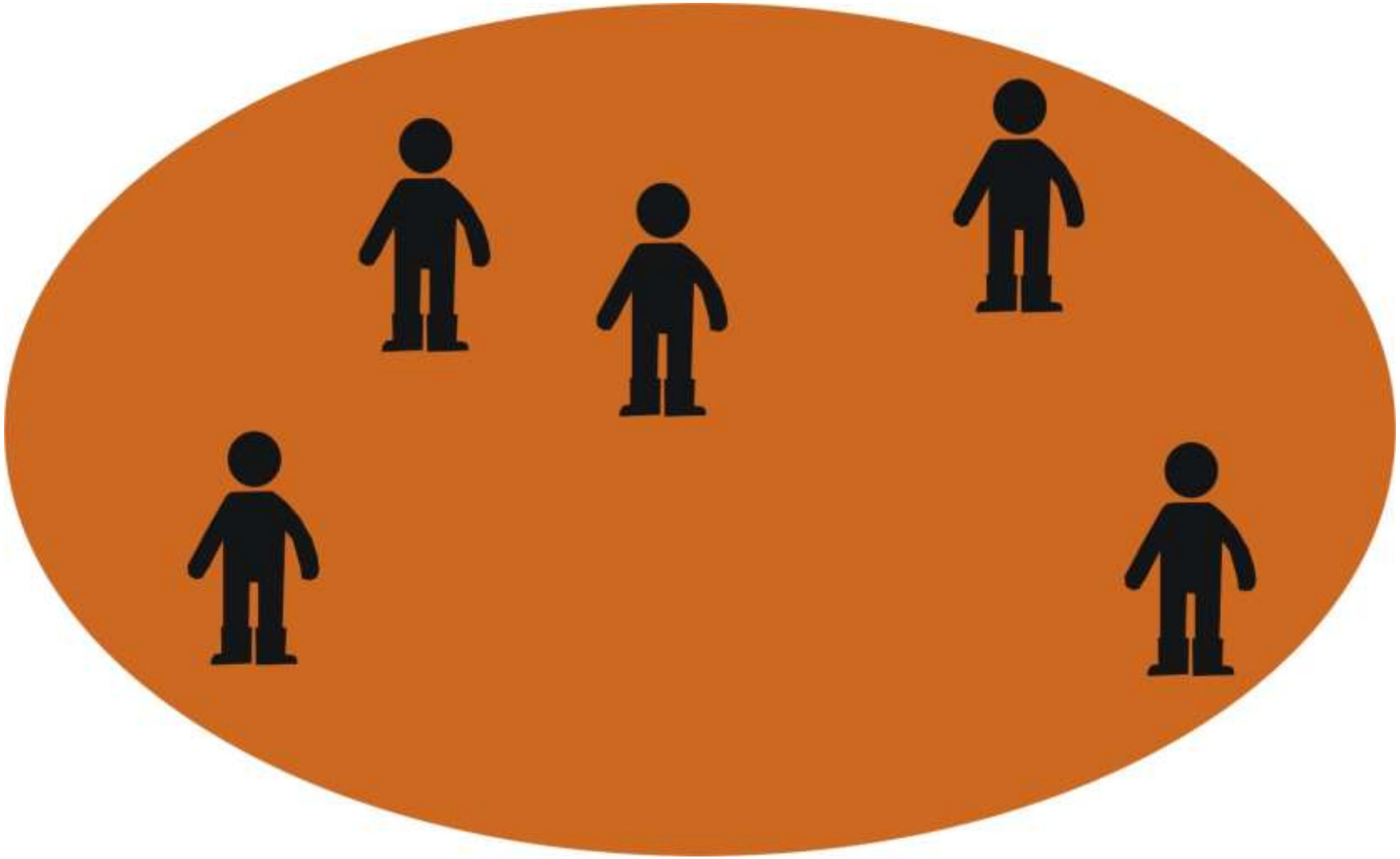

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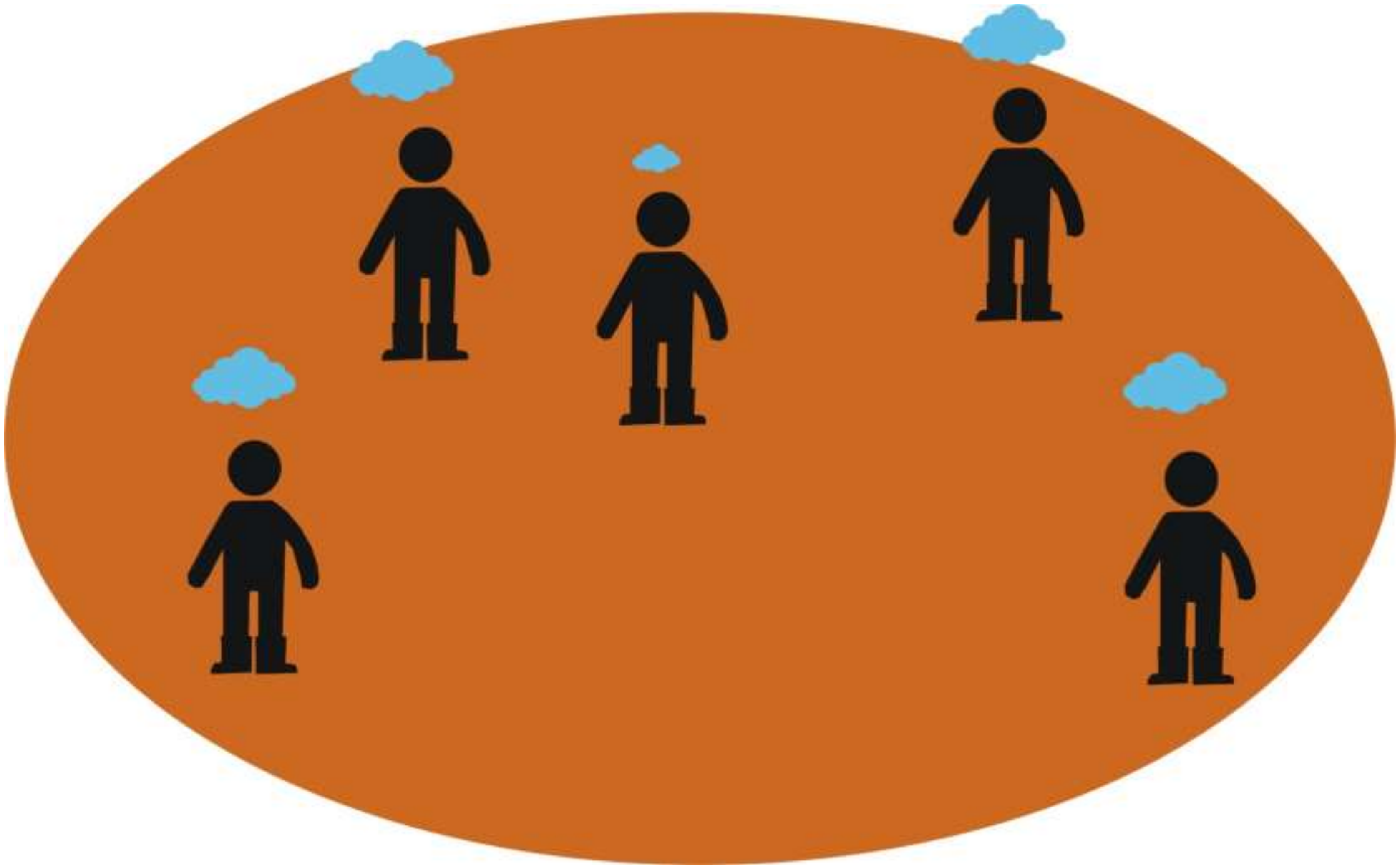

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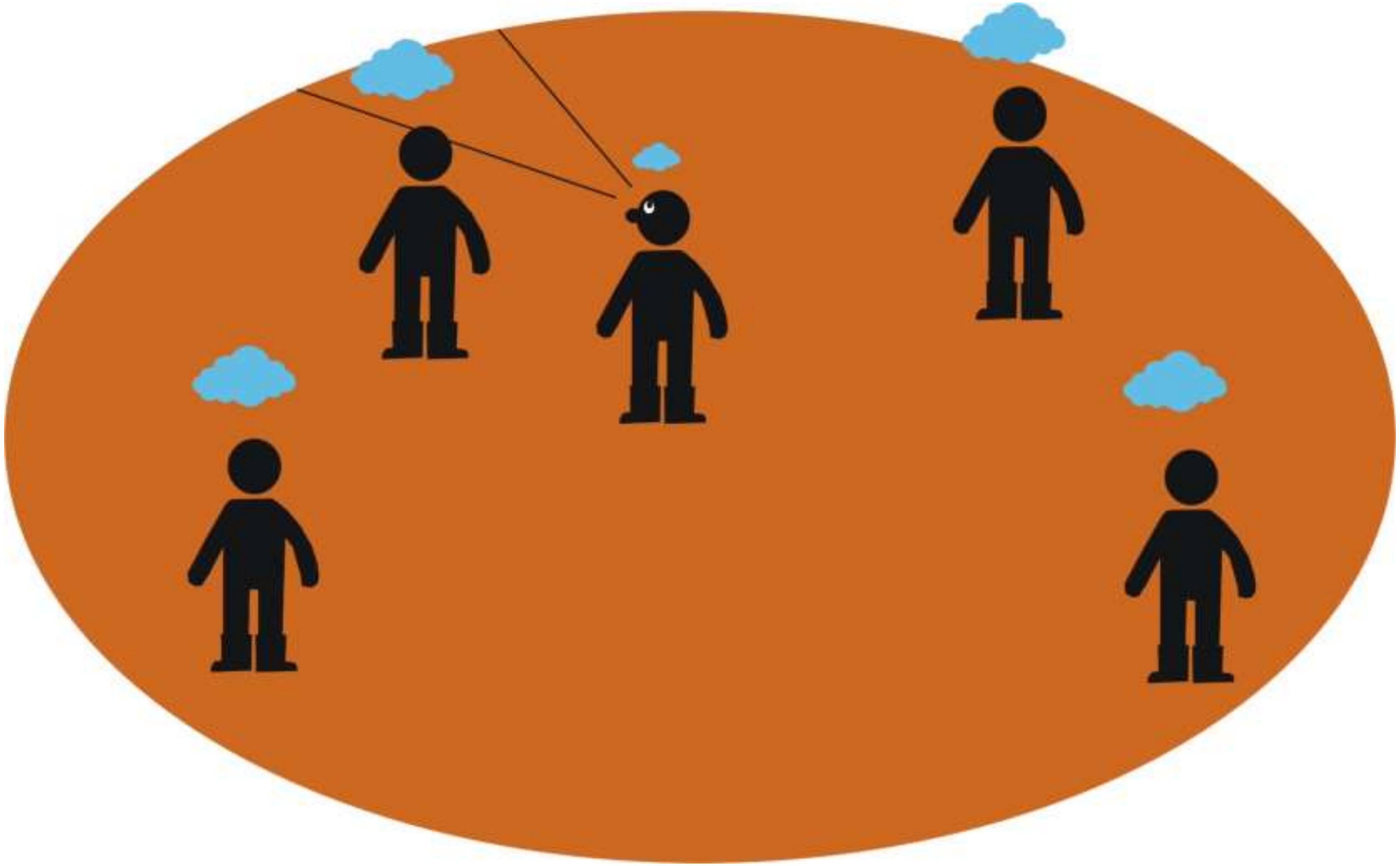

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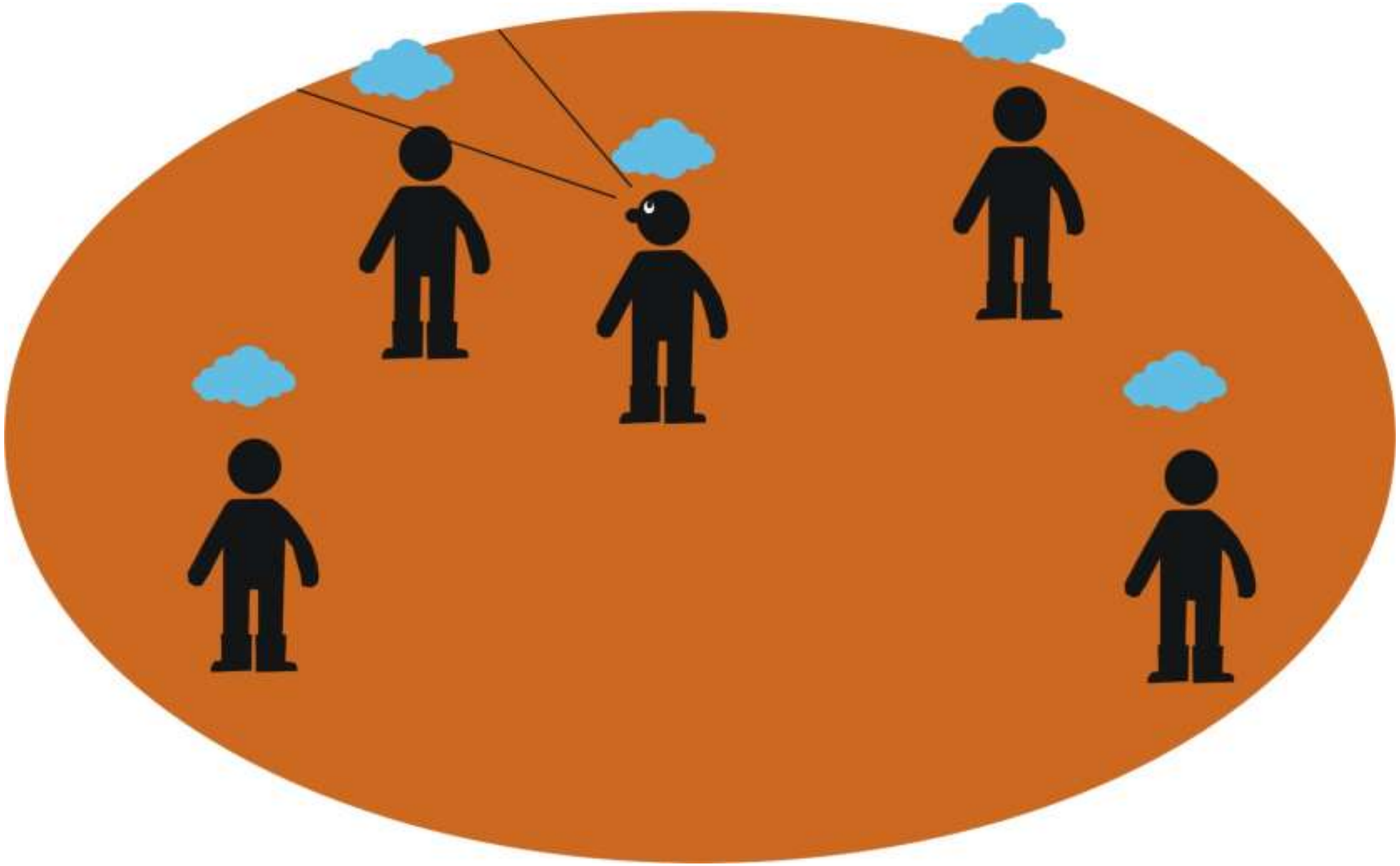
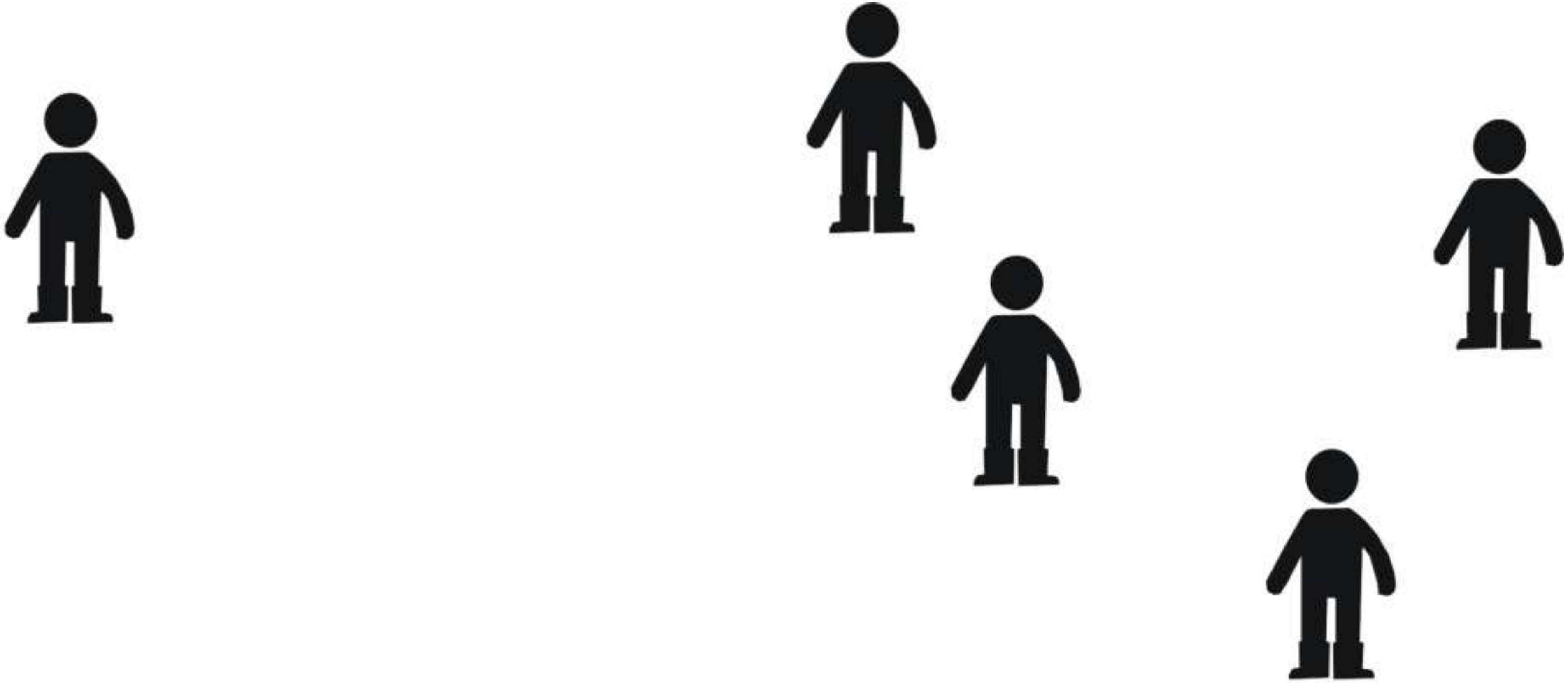
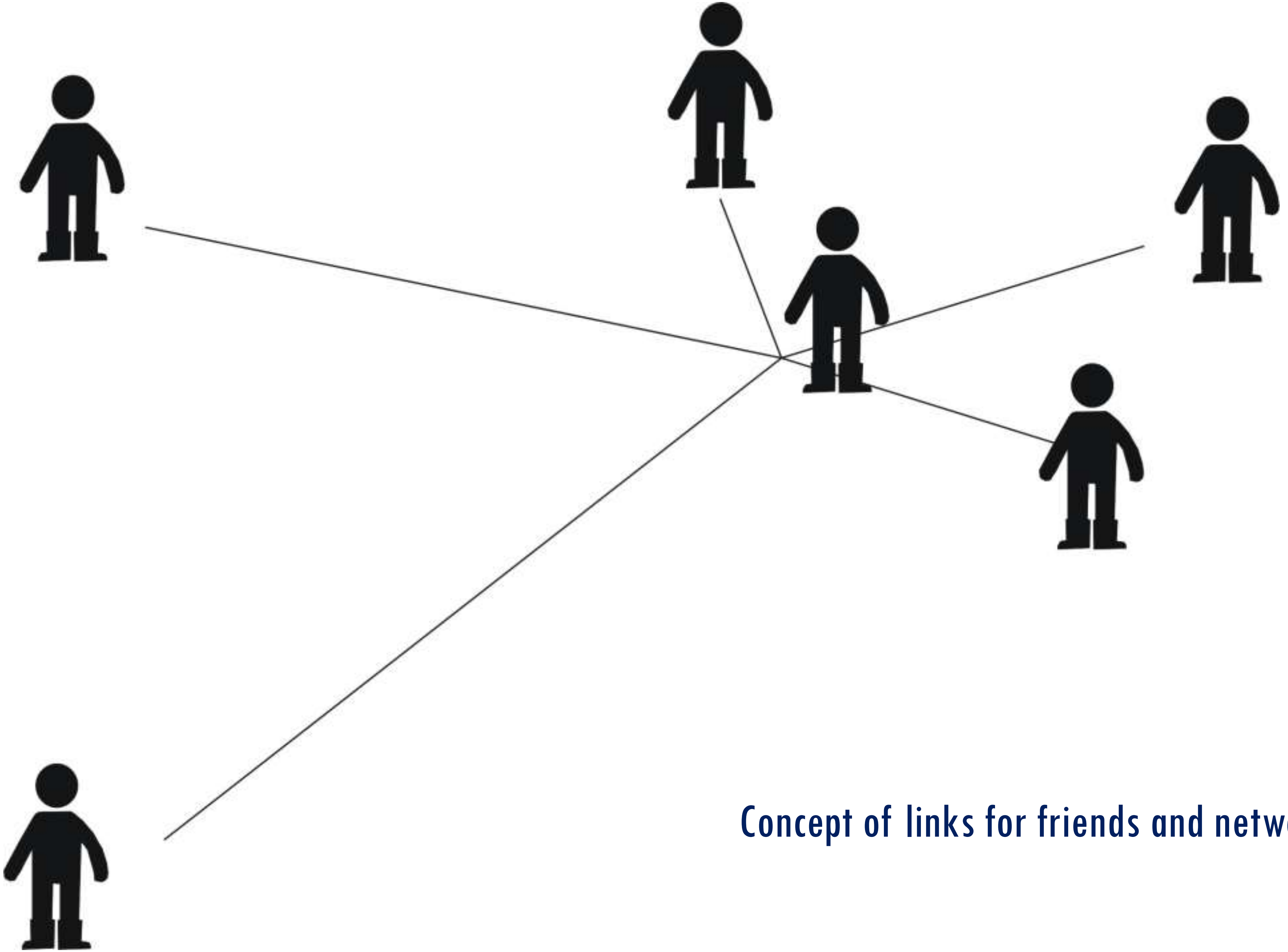




Concept of links for friends and networks



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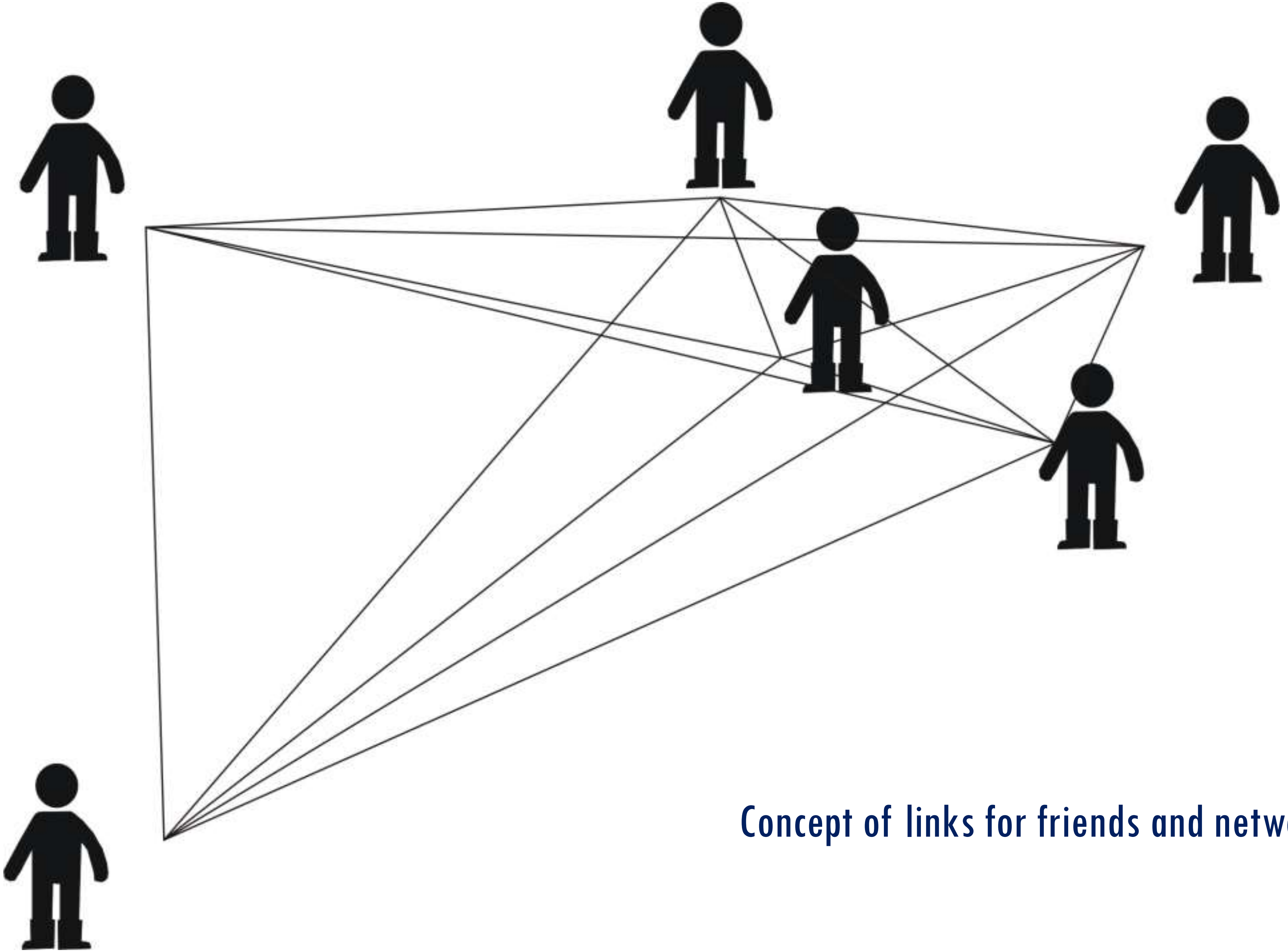

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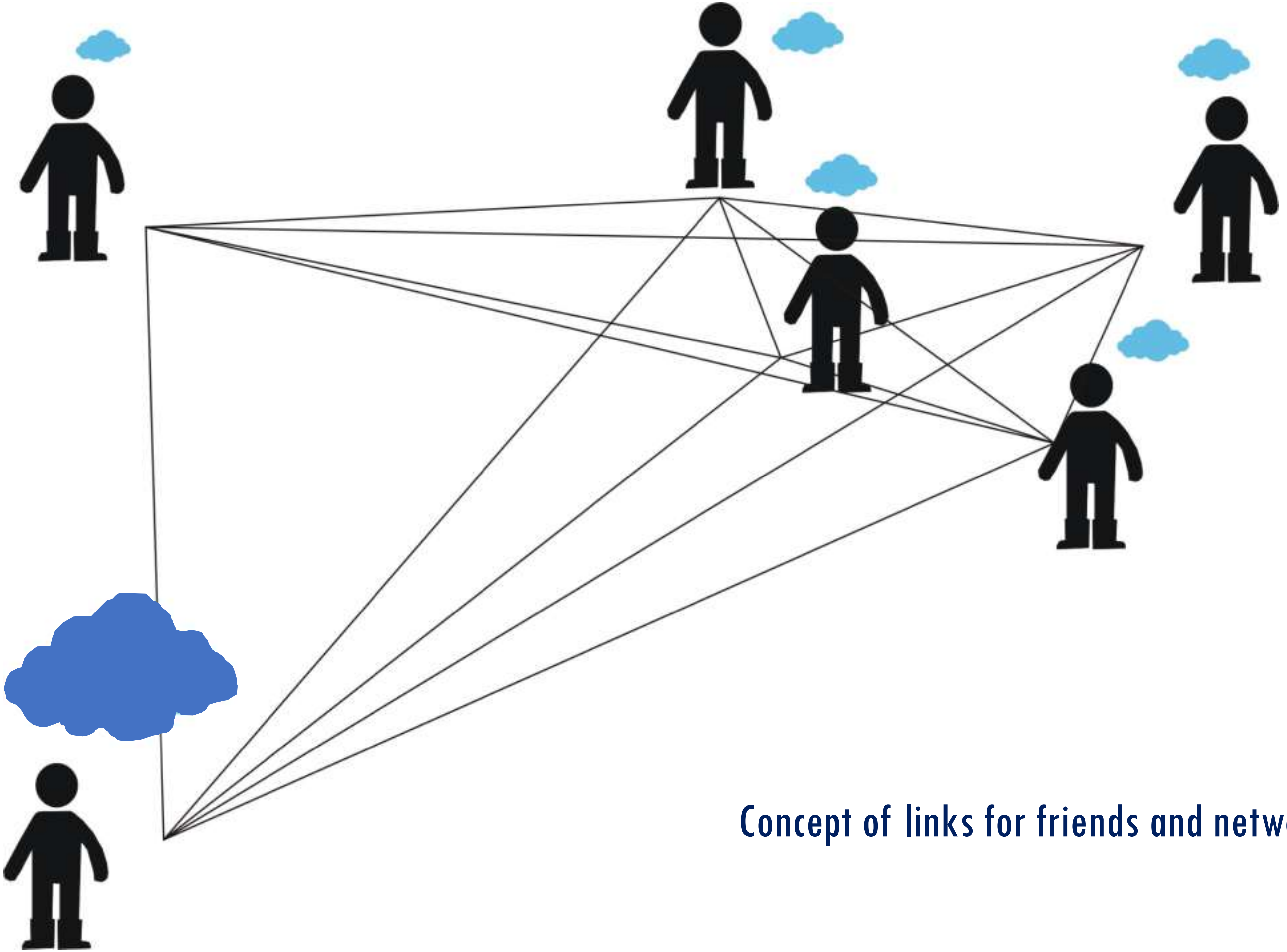

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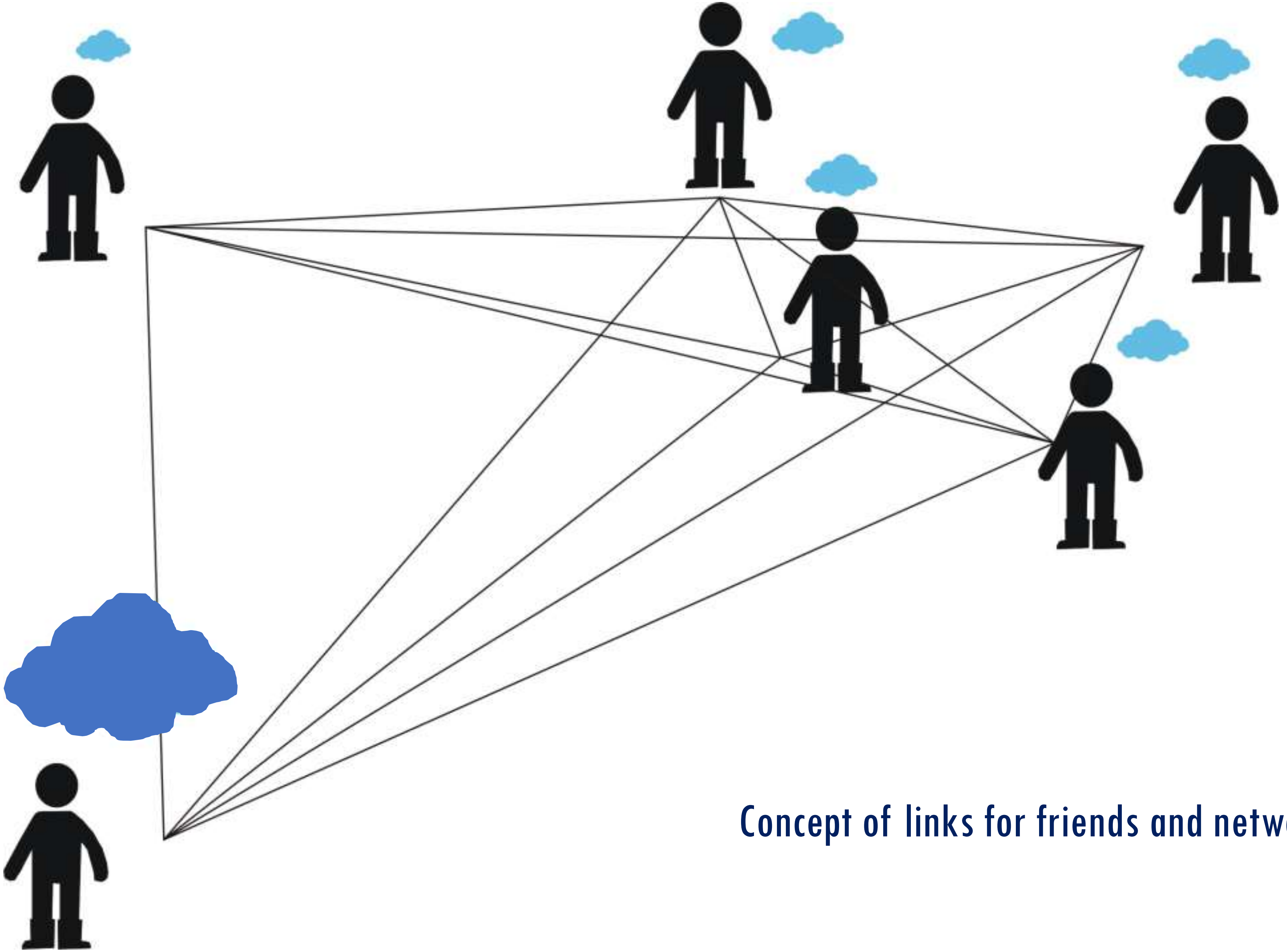

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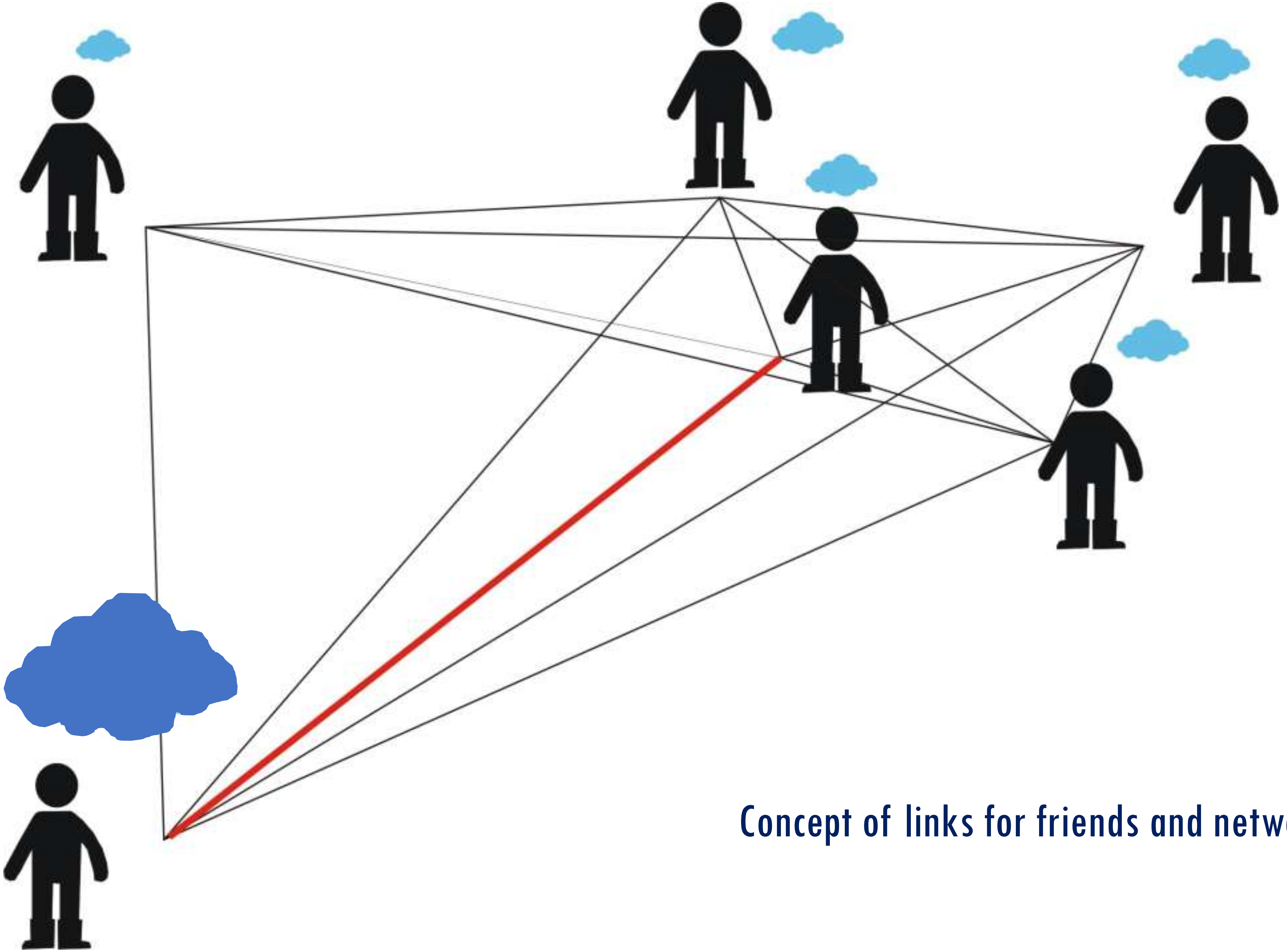

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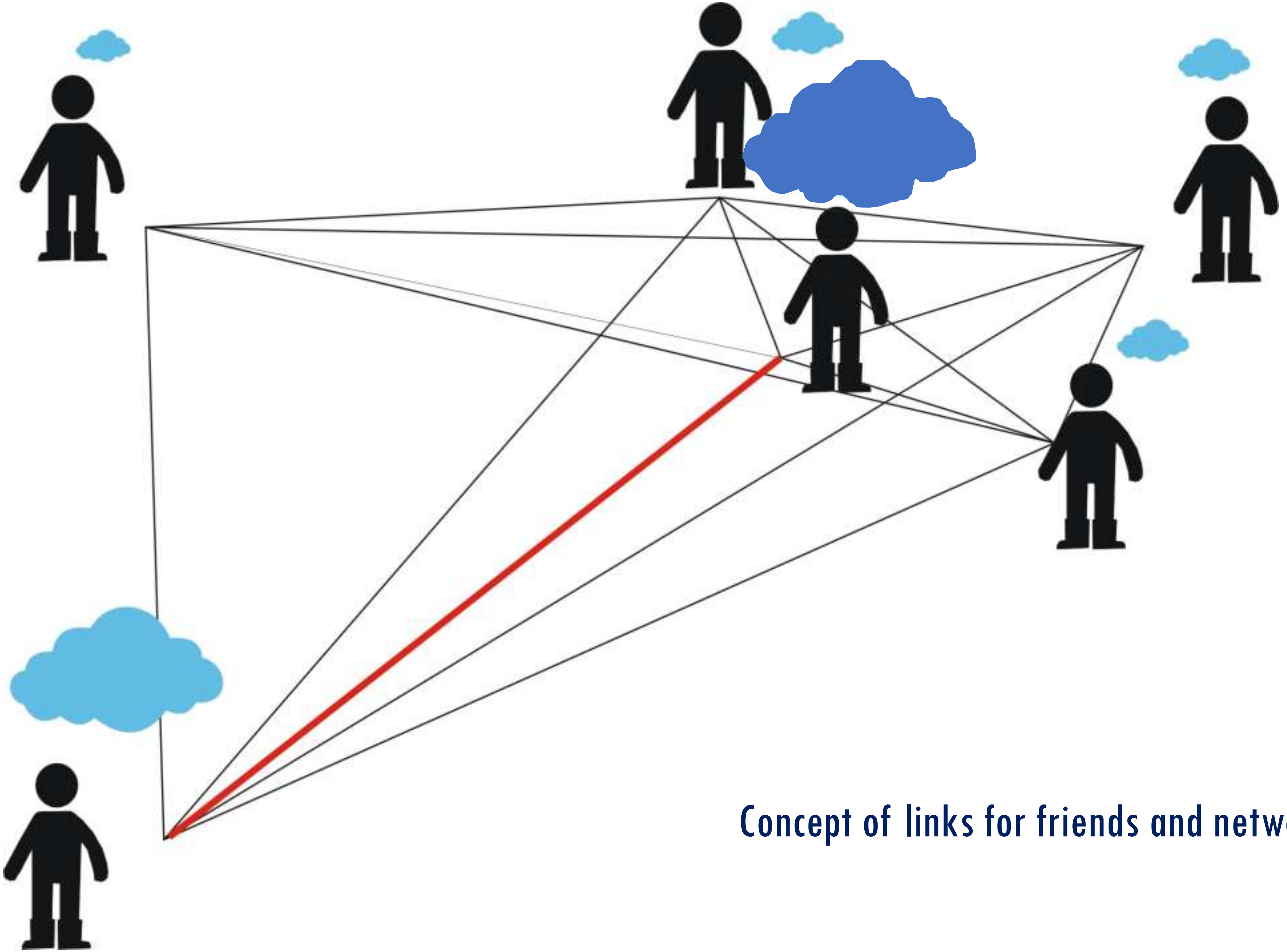

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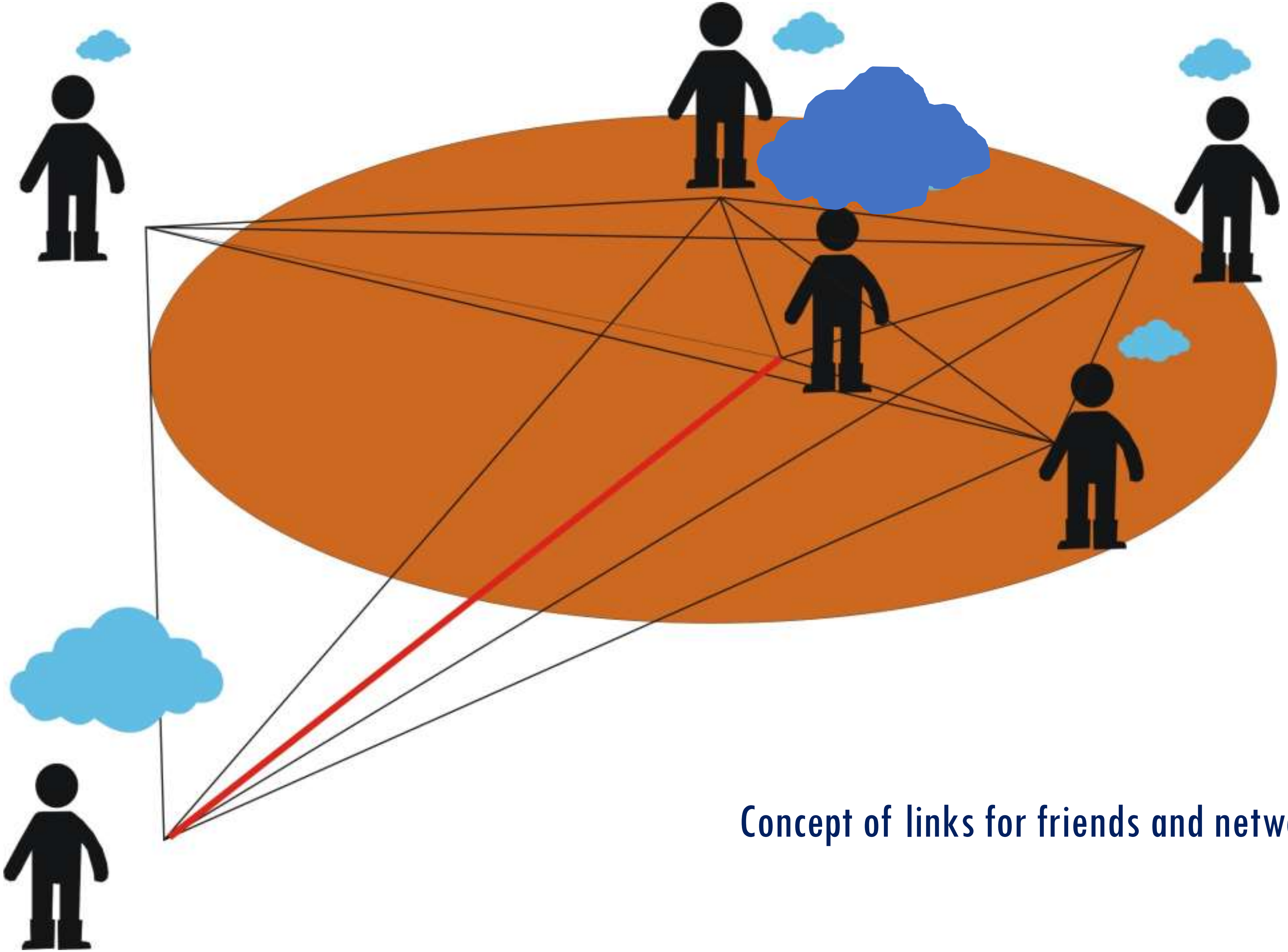


Concept of links for friends and networks

Agricultural Extension worker

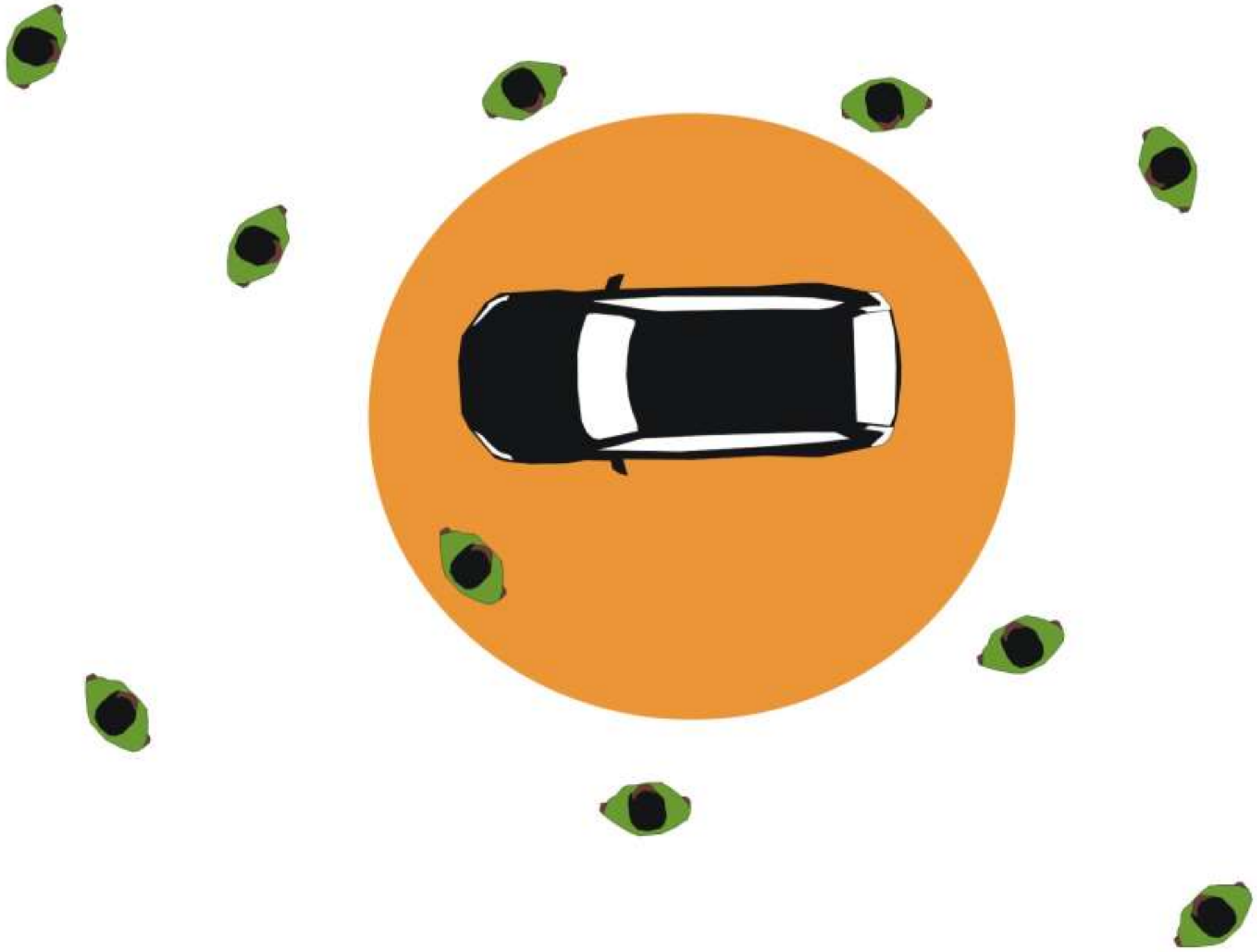
Agricultural Extension has knowledge [100]

Agricultural Extension worker has vision

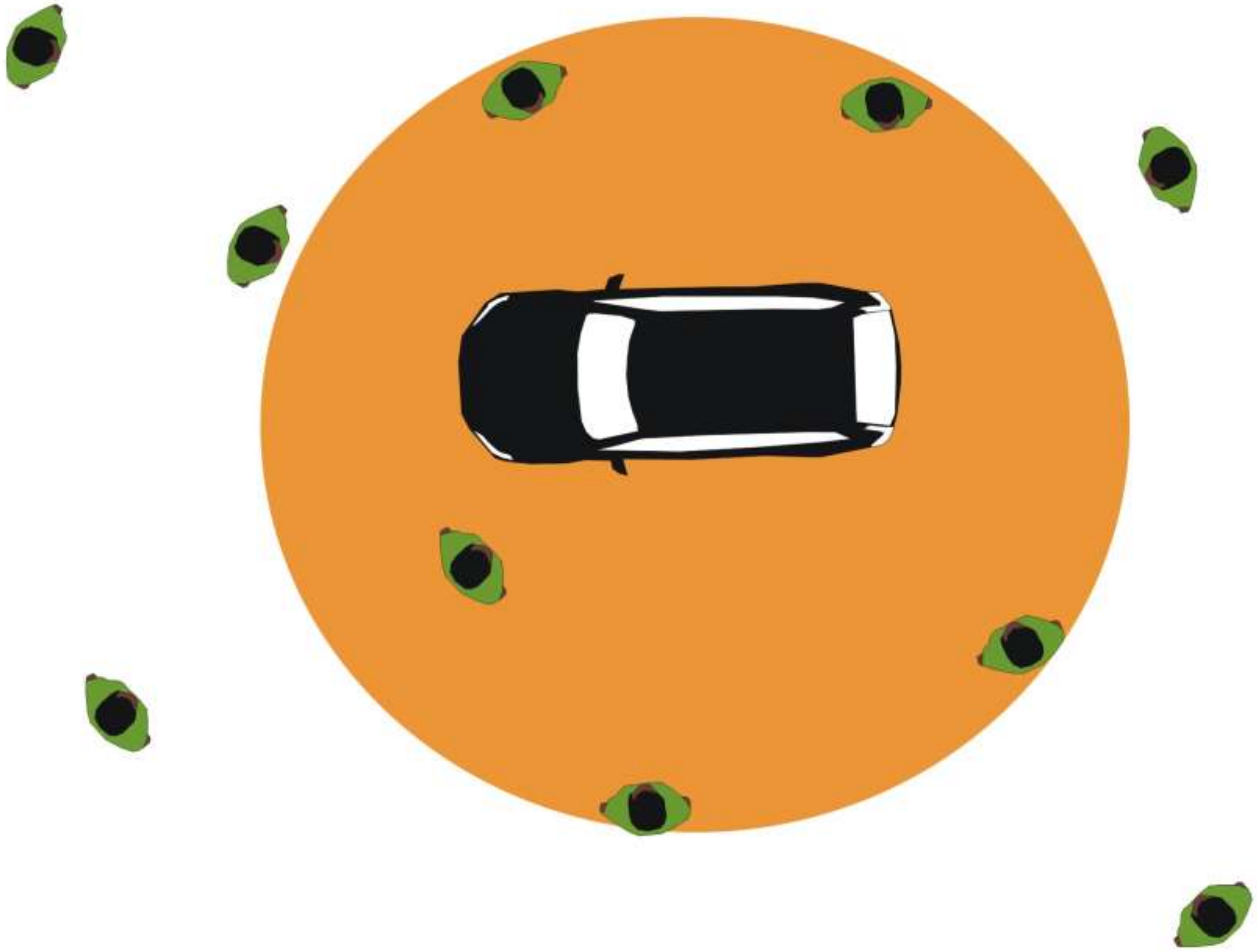
Agricultural Extension worker has speeds

Vision

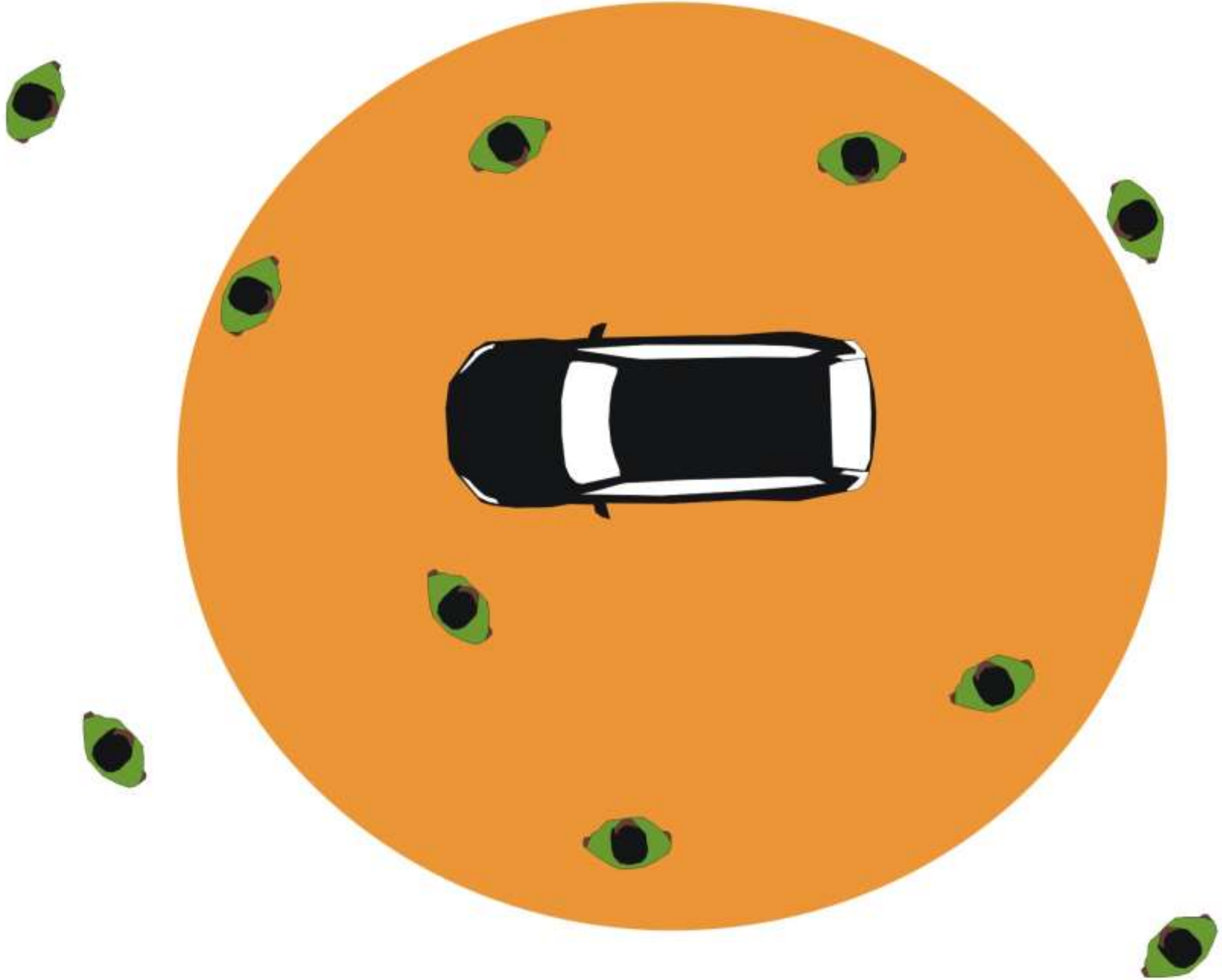
Vision



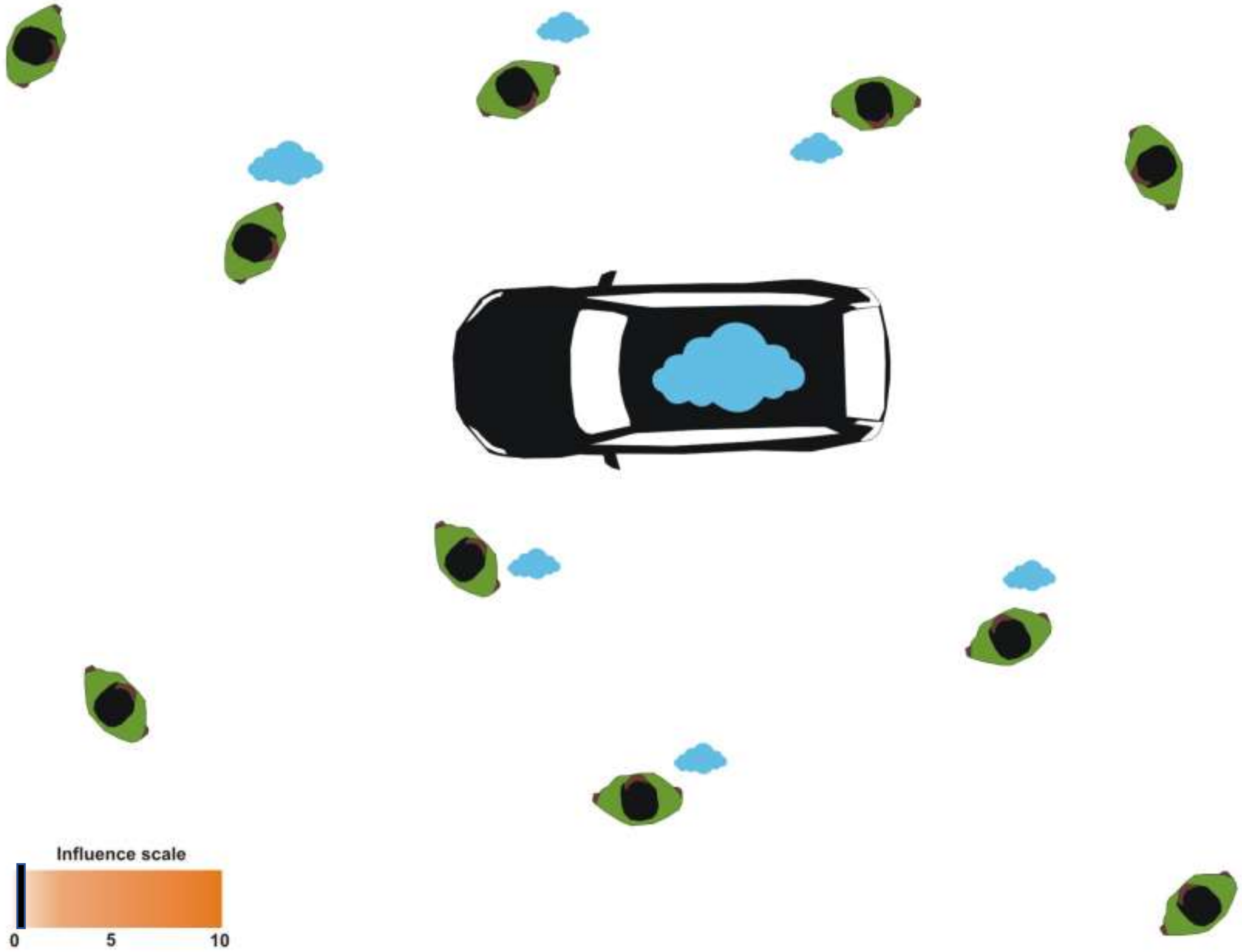
Vision



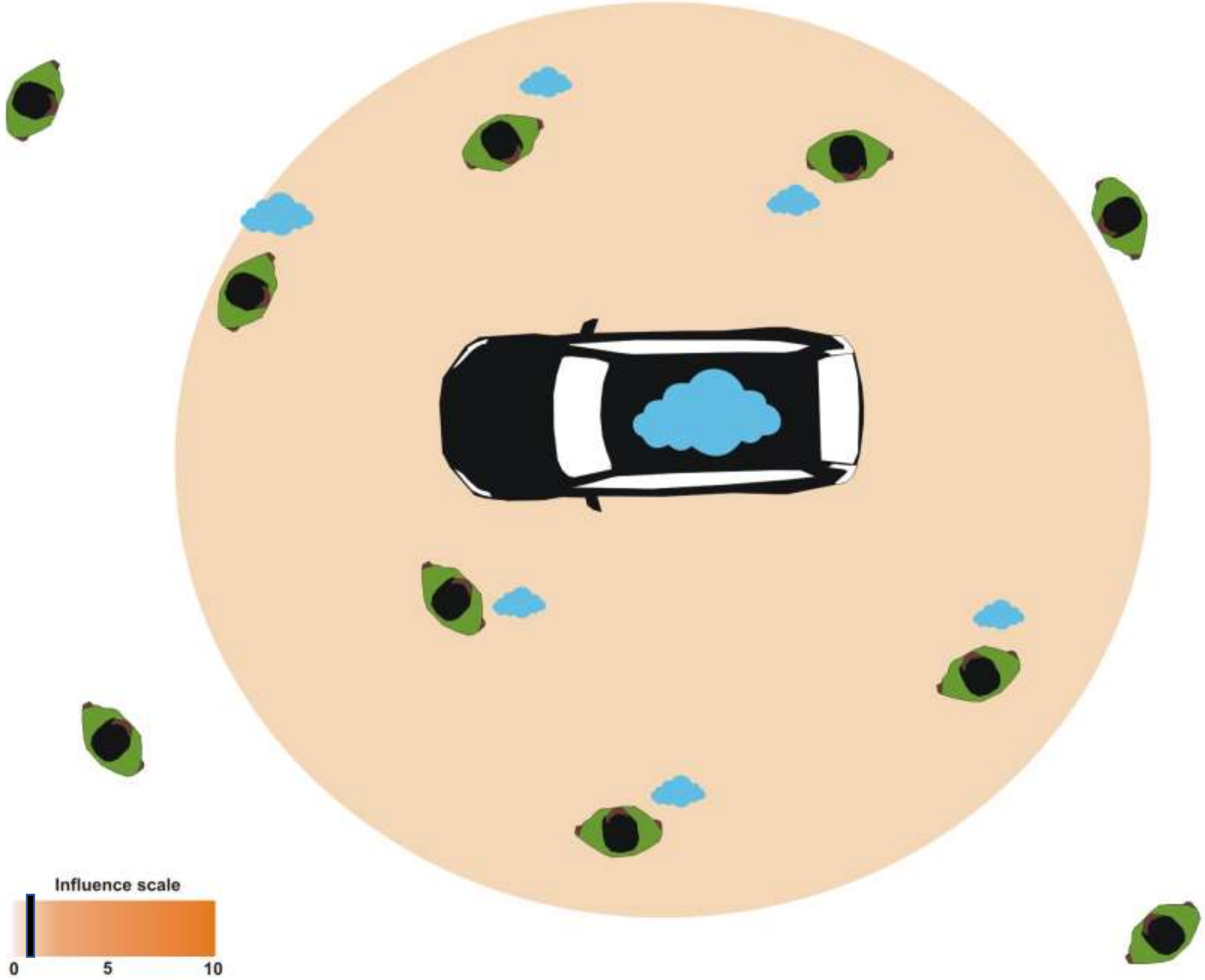
Vision



Influence

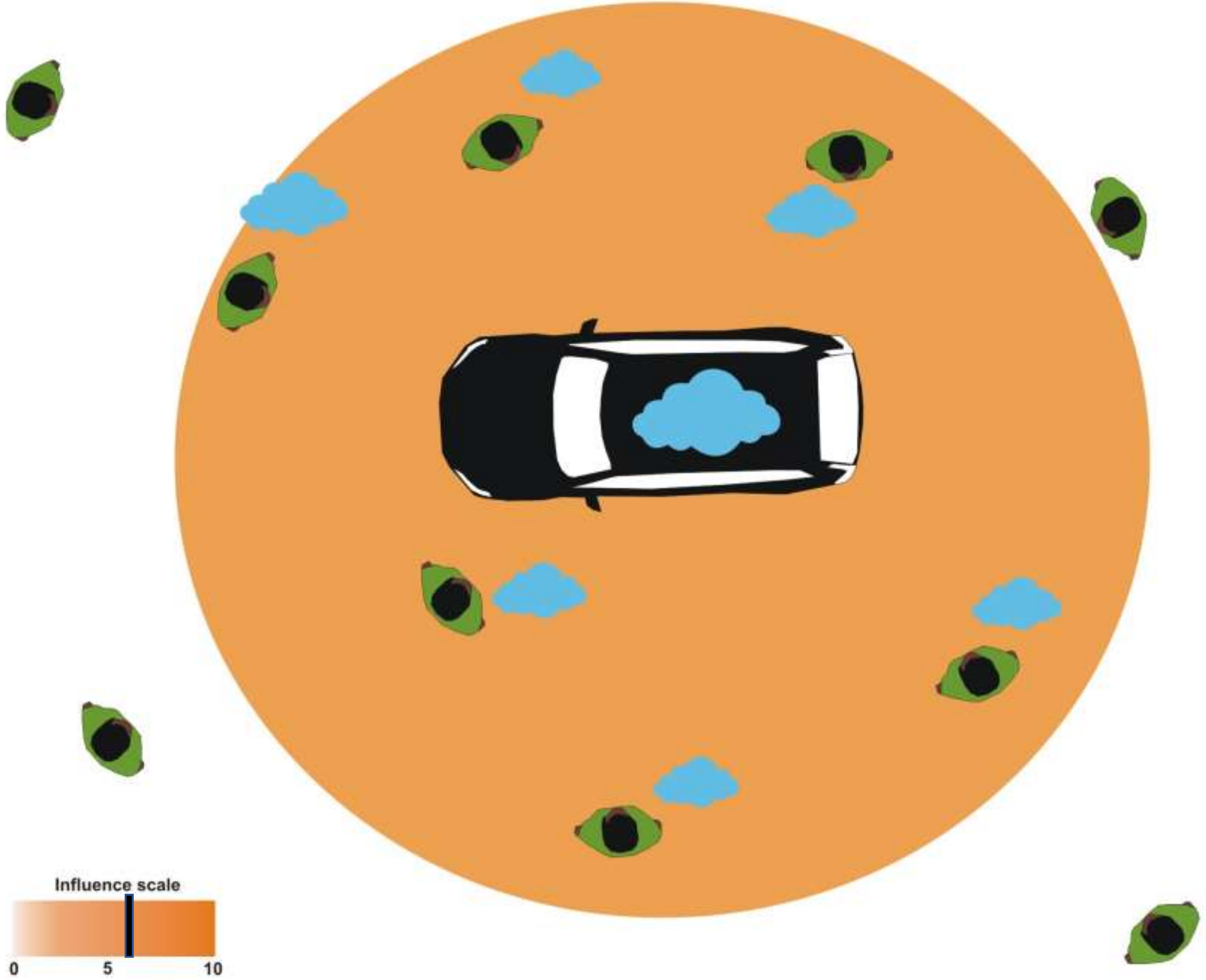


Influence

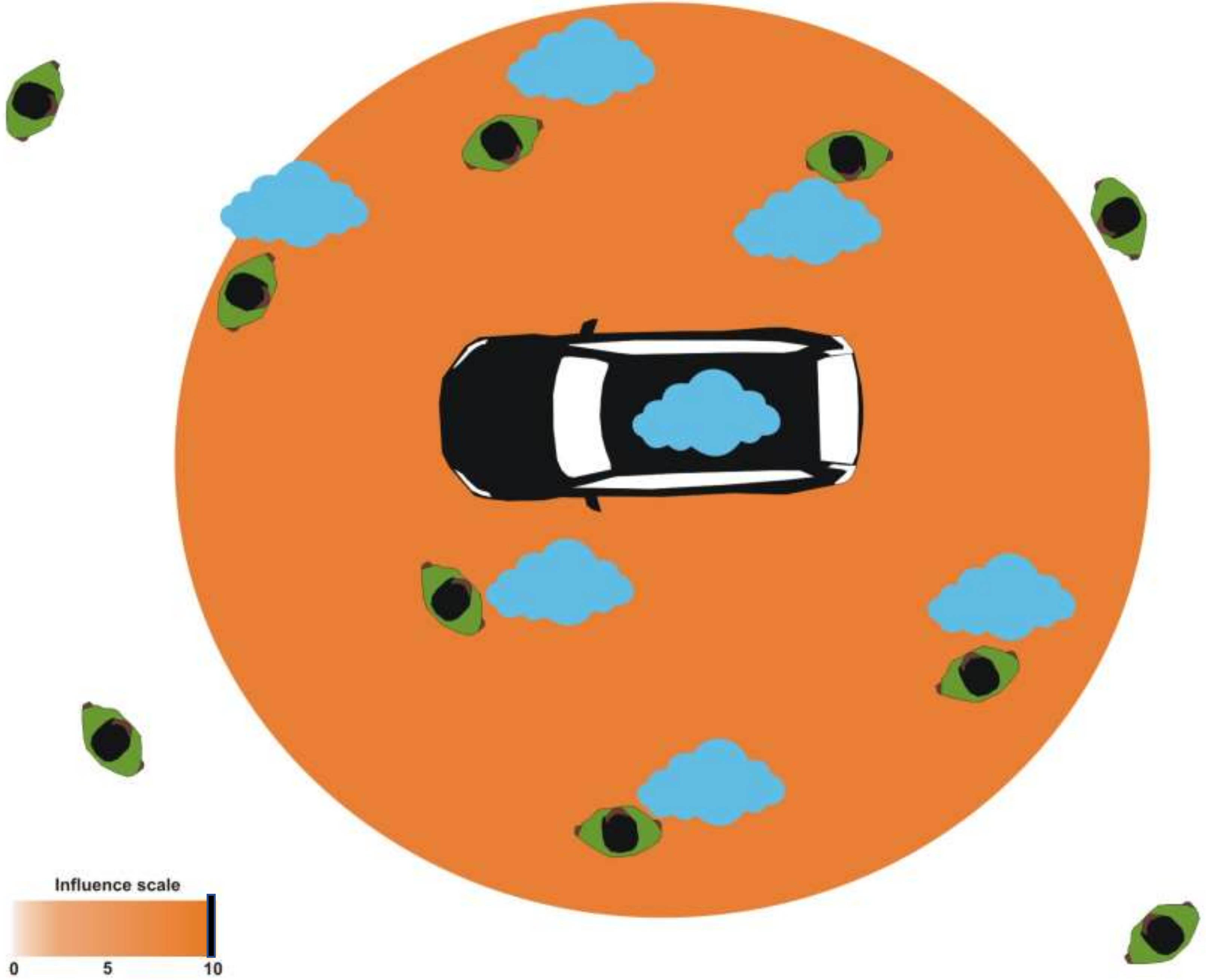


Influence

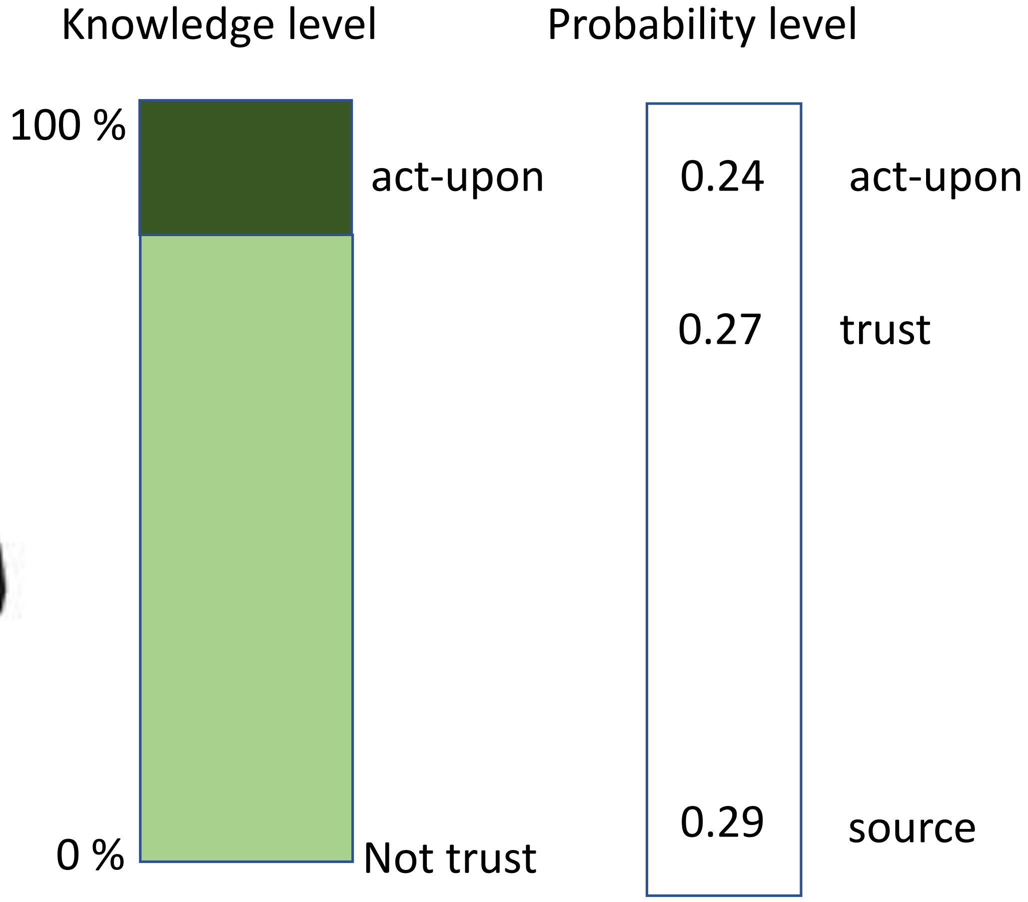
Influence



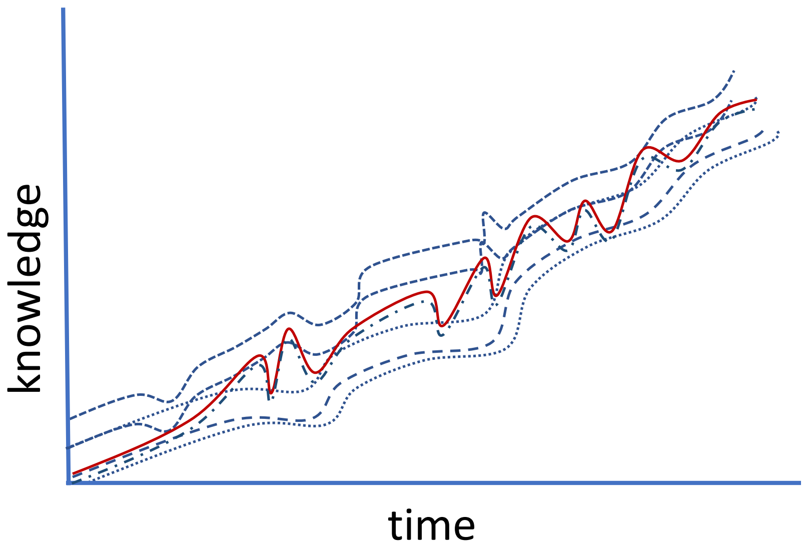
Influence

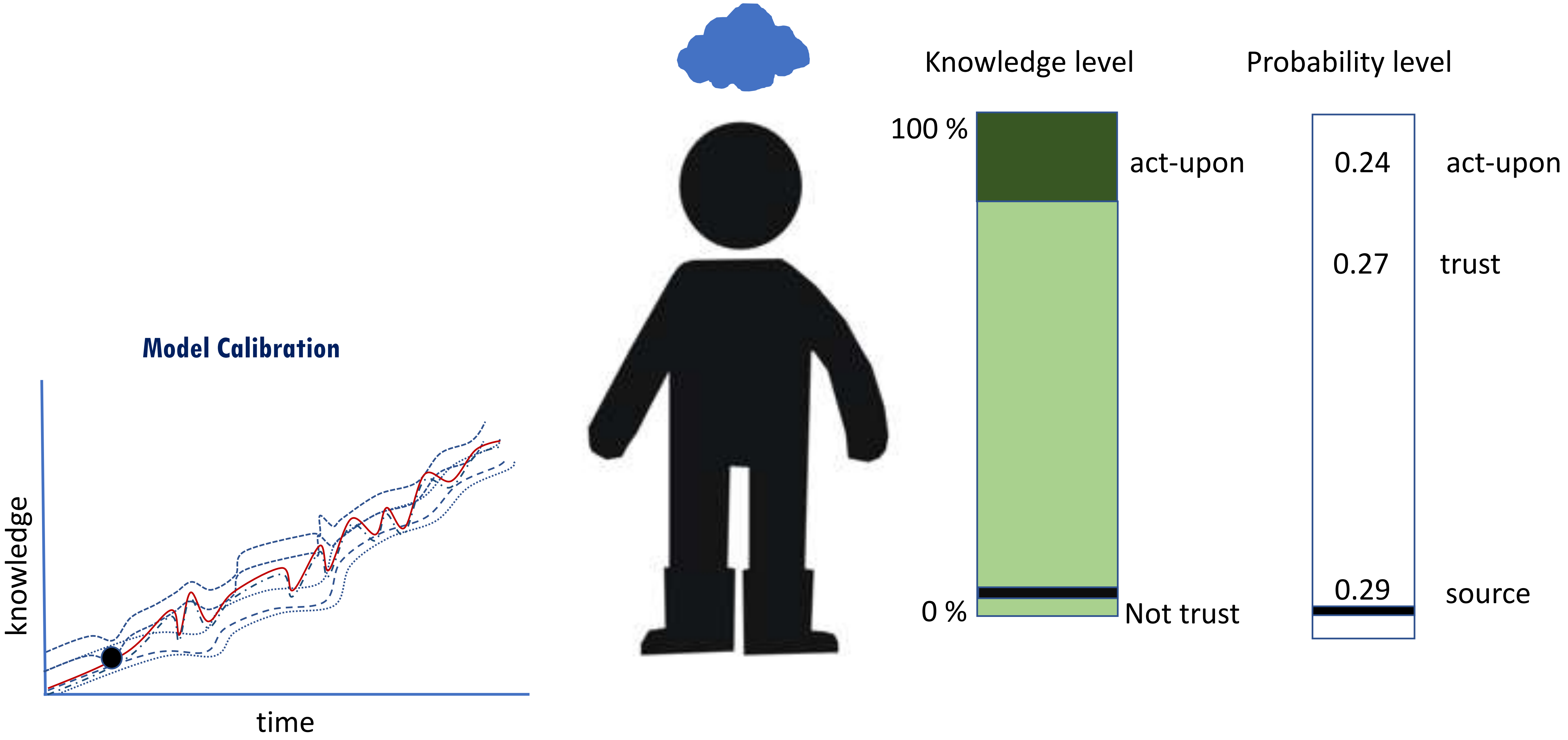


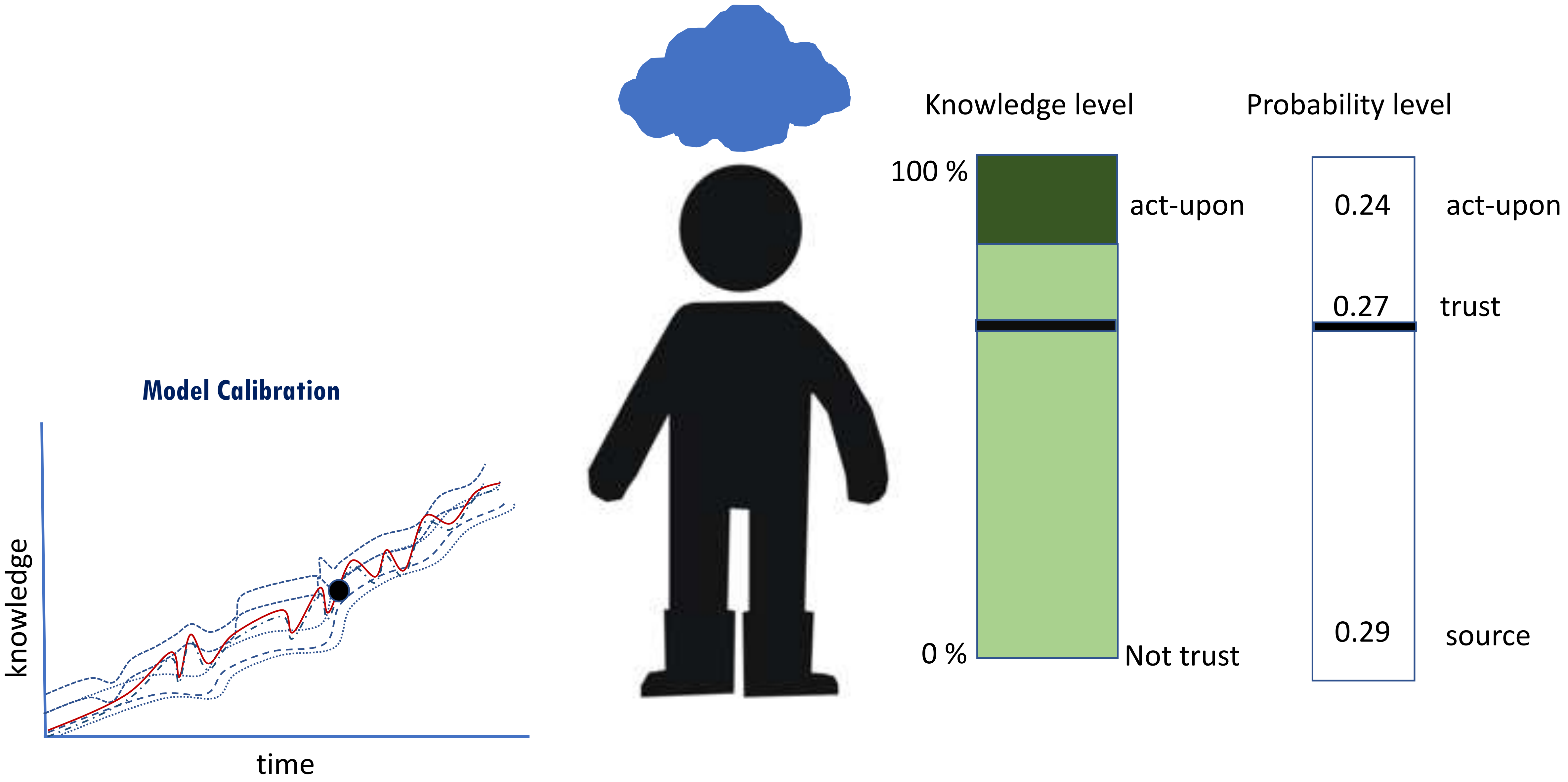
Evaluation of Knowledge Level



Model Calibration




Model Calibration
knowledge
time
Knowledge level
100 %
0 %
act-upon
Not trust
Probability level
0.24
act-upon
0.27
trust
0.29
source



Model Calibration
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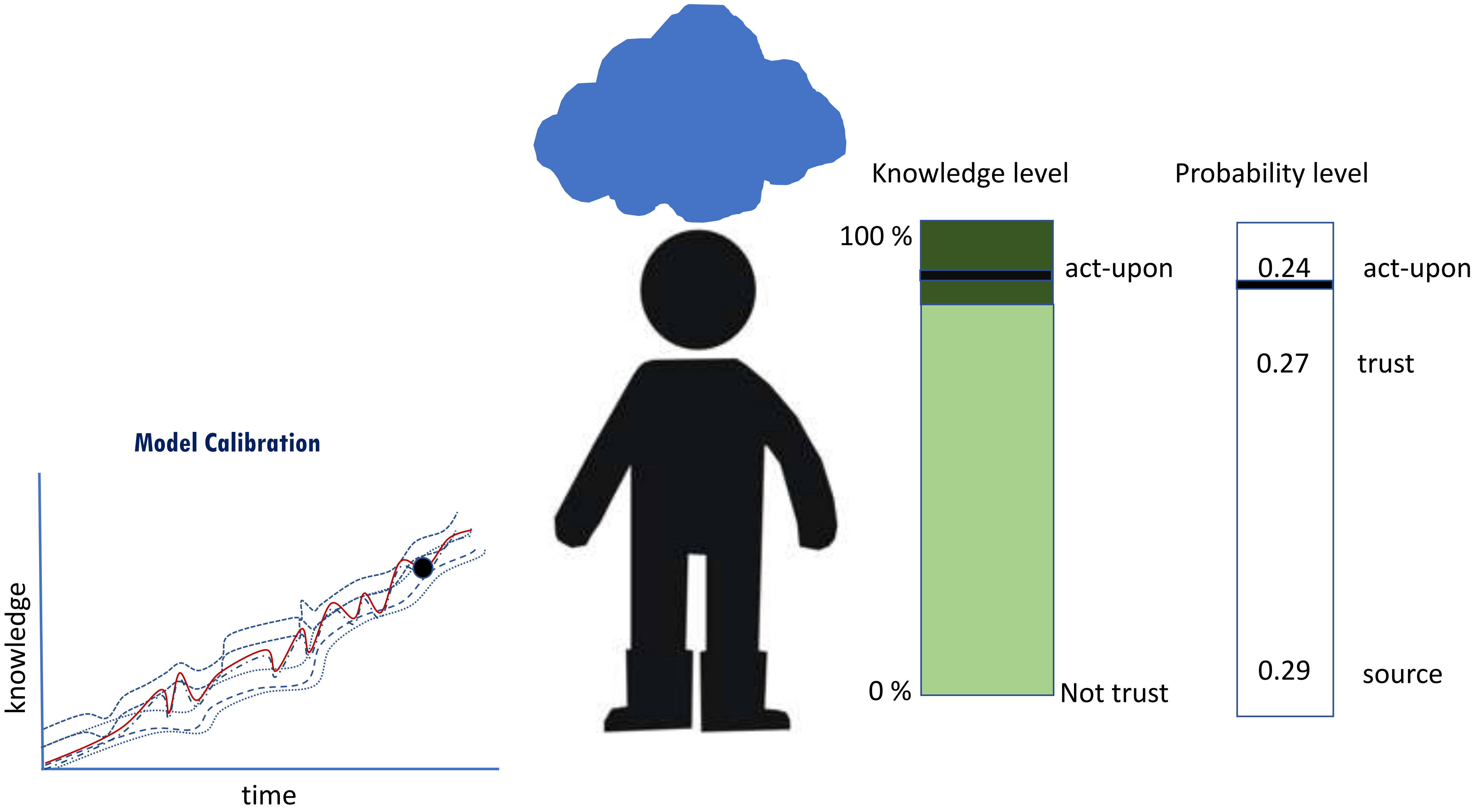
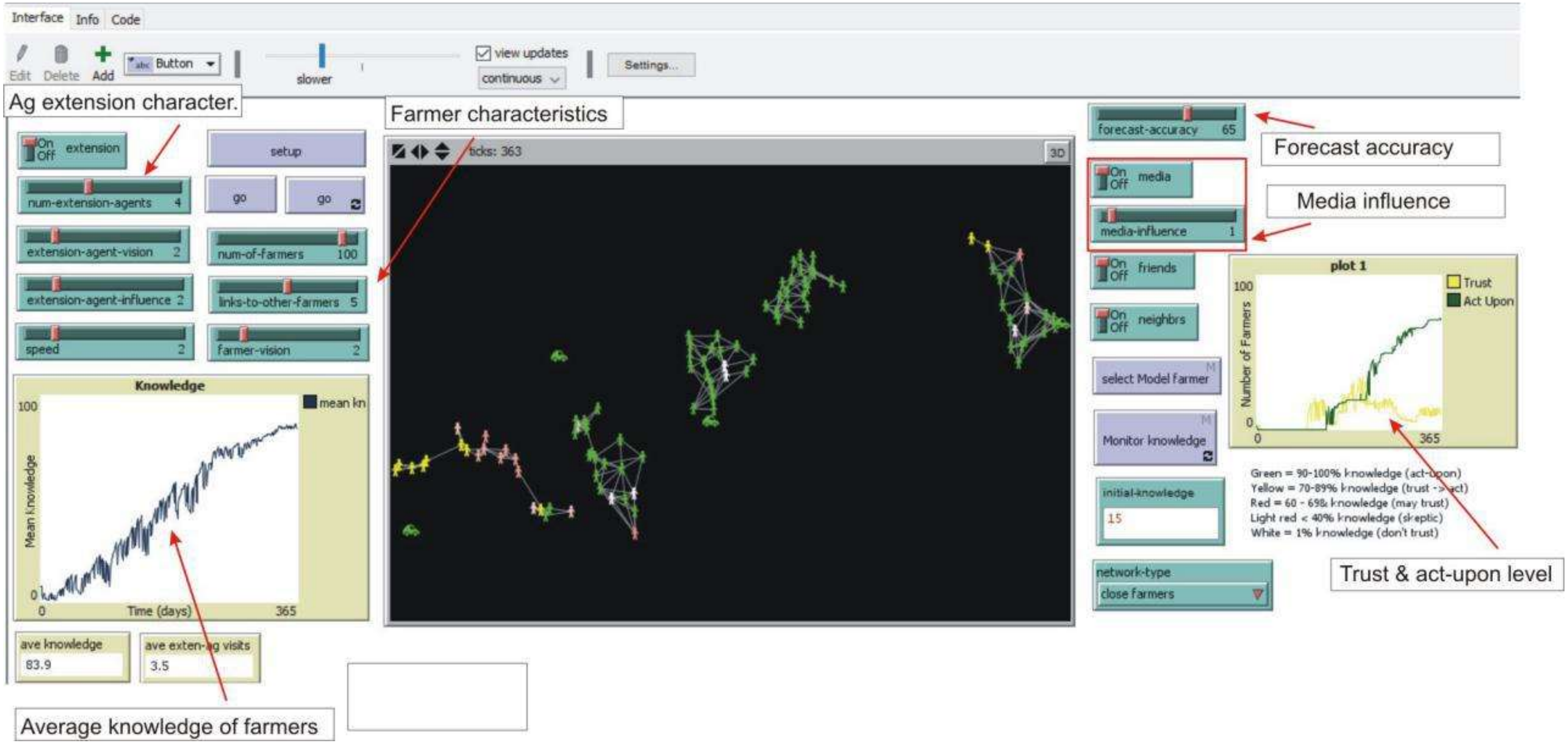

Knowledge level
Probability level
100 %
act-upon
0.24
act-upon
0.27
trust
0 %
Not trust
0.29
source
Model Calibration
knowledge
time

ABM model



Interface
Info
Code
Edit
Delete
Add
Button
slower
view updates
continuous
Settings...
Ag extension character.
Farmer characteristics
extension
setup
num-extension-agents 4
go
go
extension-agent-vision 2
num-of-farmers 100
extension-agent-influence 2
links-to-other-farmers 5
speed 2
farmer-vision 2
Knowledge
100
0
mean kn
Mean knowledge
Time (days)
365
ave knowledge
83.9
ave exten-ag visits
3.5
Average knowledge of farmers
ticks: 363
3D
forecast-accuracy 65
Forecast accuracy
media
media-influence 1
Media influence
friends
neighbrs
select Model farmer
Monitor knowledge
initial-knowledge
15
network-type
close farmers
plot 1
Trust
Act Upon
Number of Farmers
Green = 90-100% knowledge (act-upon)
Yellow = 70-89% knowledge (trust -> act)
Red = 60 - 69% knowledge (may trust)
Light red < 40% knowledge (skeptic)
White = 1% knowledge (don't trust)
Trust & act-upon level

Upcoming Plans:

- Analyze of agro climatic section of field survey
- Calibrate the model
- Identify influence level of each agents
- Set up baseline scenario based on survey results and conduct experiments varying variables:
  - number of farmers
  - farmer's vision
  - number of links to other farmers
  - number of extension agents
  - influence of extension agents, speed
  - media influence
  - forecast accuracy
- Predict farmers decisions on agricultural productivity

Forecast Dissemination

Ezana Atsbeha
Water & Food Security Project PIRE

3rd Annual Meeting

November 21 - 22, 2019

The Product

- April – May 2019: Kiremt forecast for Kudmi, Reem, Gayta, Dangeshta
  - Workshopped with farmers at Dangila, feedback gathered at North Mecha, disseminated in all project kebeles
- September – October 2019: Bega forecast for Kudmi and Gayta
  - Feedback gathered at ABA, Koga; disseminated at ABA, Koga, Kudmi, Gayta

Kiremt Forecast: communicating probabilistic information

- Both men stated that they found the bulletin easy to understand. However, both men understood the calendar in column two as presenting the *amount* of rainfall forecasted to fall on the indicated days, and the pie chair as proportions of rainy days with the indicated rainfall amount. Even after I explained the information contained as being probabilities, the continued to refer to the information contained as amount throughout the discussion.
- [field note, discussion on first draft of bulletin at kudmi April 2019]

Using examples related to farmers' lives

Communicating probabilistic information

- **Textual information versus graphic information**

[ag. Expert] presented the onset forecast to the participants. He mostly read from the bulletin and explained the forecast as it was presented in the previous meetings, save for a minor mistake in presenting the exact dates corresponding with the probability. Because he was reading, he did not have the opportunity to mix up probability with amount.

He however, miscommunicated the probability of total amount of rainfall while explaining the pie chart. He presented it as ‘if there are 120 days in the rainy season of four months, 50% will have normal, 30% heavy, and 20% dry rain’.

Bega Forecast

- Main message – dam is full, good river flow – similar release pattern understood easily.
- But, often, conversation shifted to complicated issues of water release apart from water availability
  - Single scenario model – willingness to refer back to bulletin at end of season
  - Release based on crop coverage: 300 ha cultivated during kiremt, to be harvested in Bega, need up to 3500 l/s in Tikimit
  - Gayta: why save water, it won't be stored anyway.

Bega forecast

- Need for more information from experts
  - What model is used
  - Moisture duration
  - Sedimentation
- Companion document was useful

Formalizing bulletin dissemination

- Farmers other that the one's trained by the research team did not hear about our forecast [kudmi and Dangeshta]
- Need to work with regional and woreda agriculture bureaus to embed forecast dissemination in day-to-day extension work

Conclusion

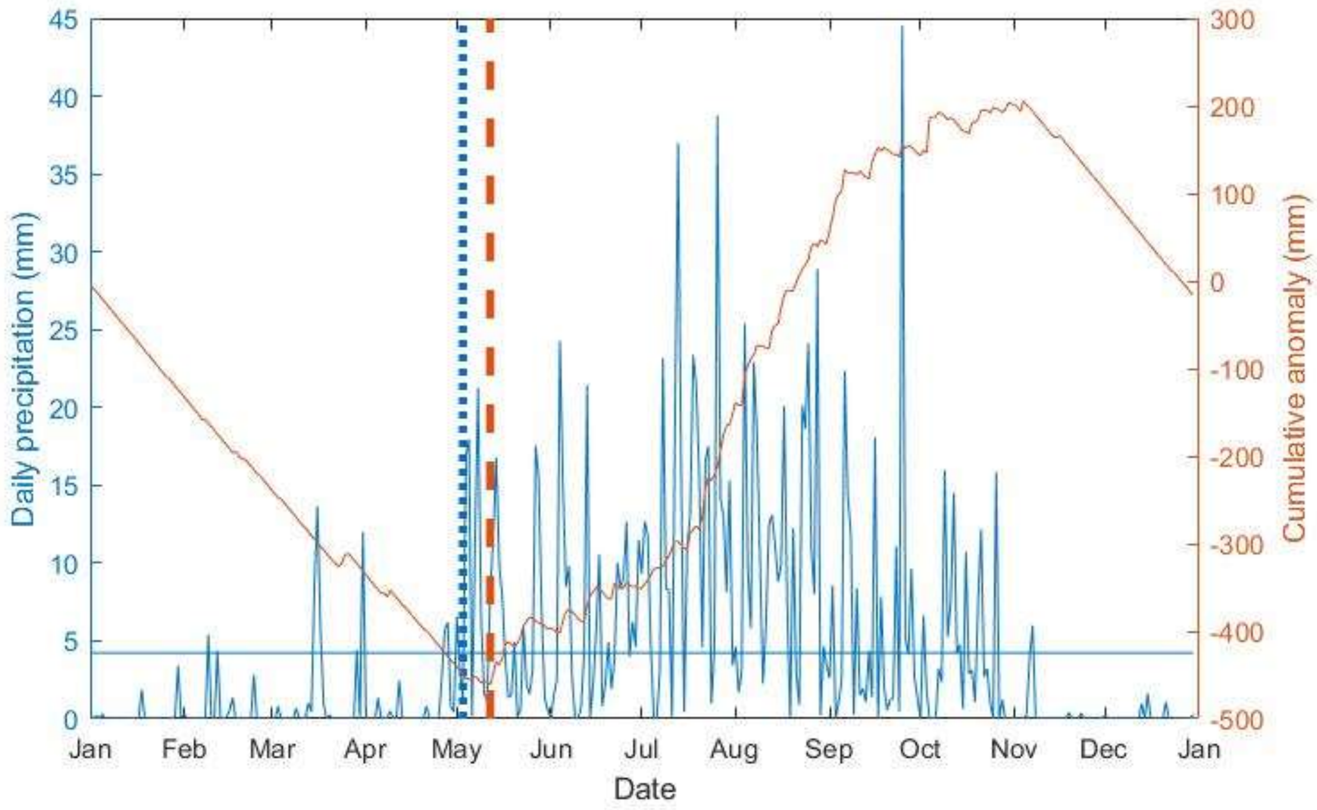
- Train influential farmers in bulletin information
- Provide textual information to extension agents
- Consider forecast as one aspect of agricultural development – rethink how forecast is affected by and affects wider concerns in irrigation

Statistical forecasting of the Kiremt onset in Koga

Jonathan Lala – University of Wisconsin - Madison

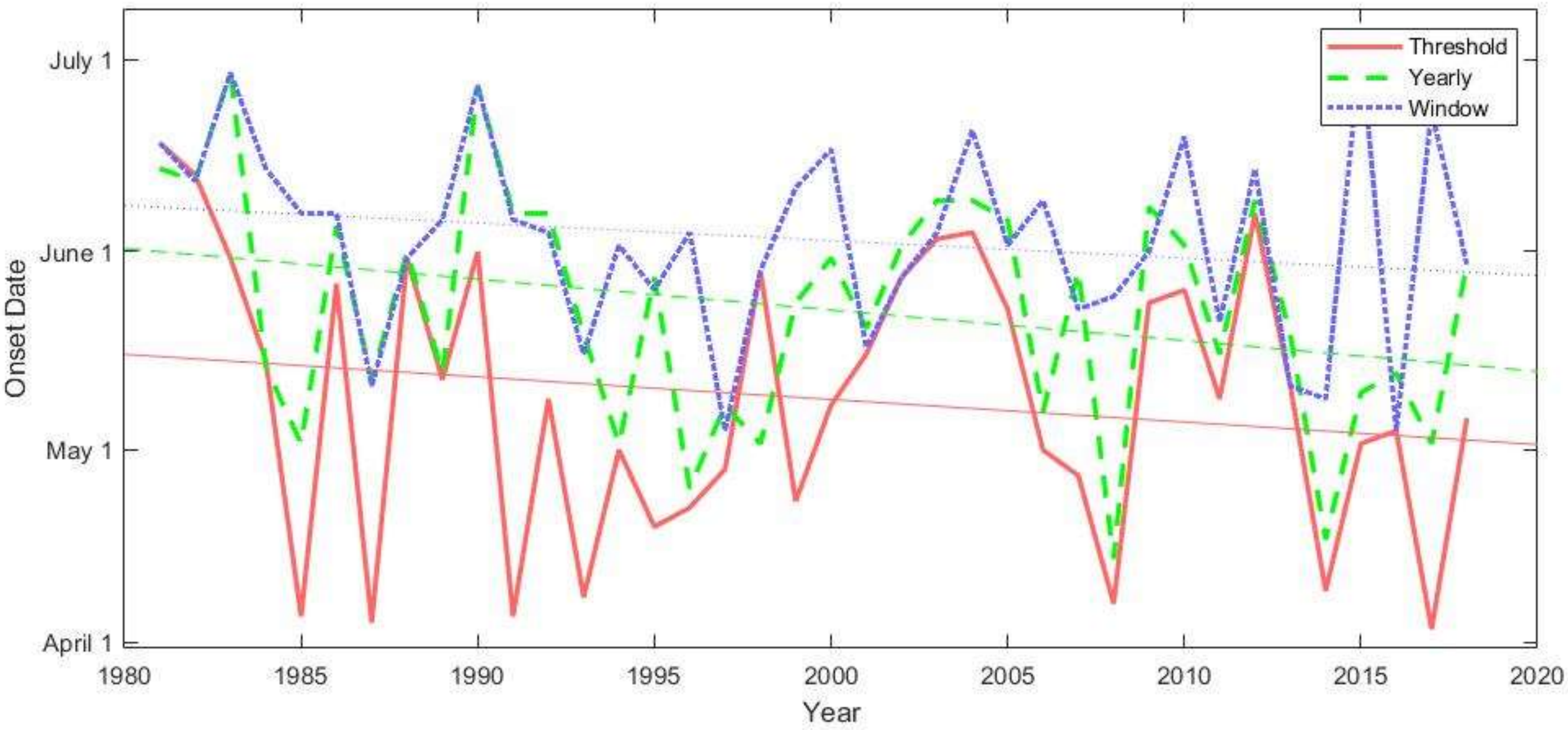
Defining onset

1. Threshold
   - 3 days in a row with at least 20 mm precipitation, and no dry spells (< 0.1 mm each day for at least 8 days) in next 30 days
2. Anomaly – Yearly
   - Cumulative anomaly of daily precipitation over long-term average, onset = max cumulative anomaly for a given year
3. Anomaly – Window
   - Same as yearly method, but centered on April-July instead of whole year

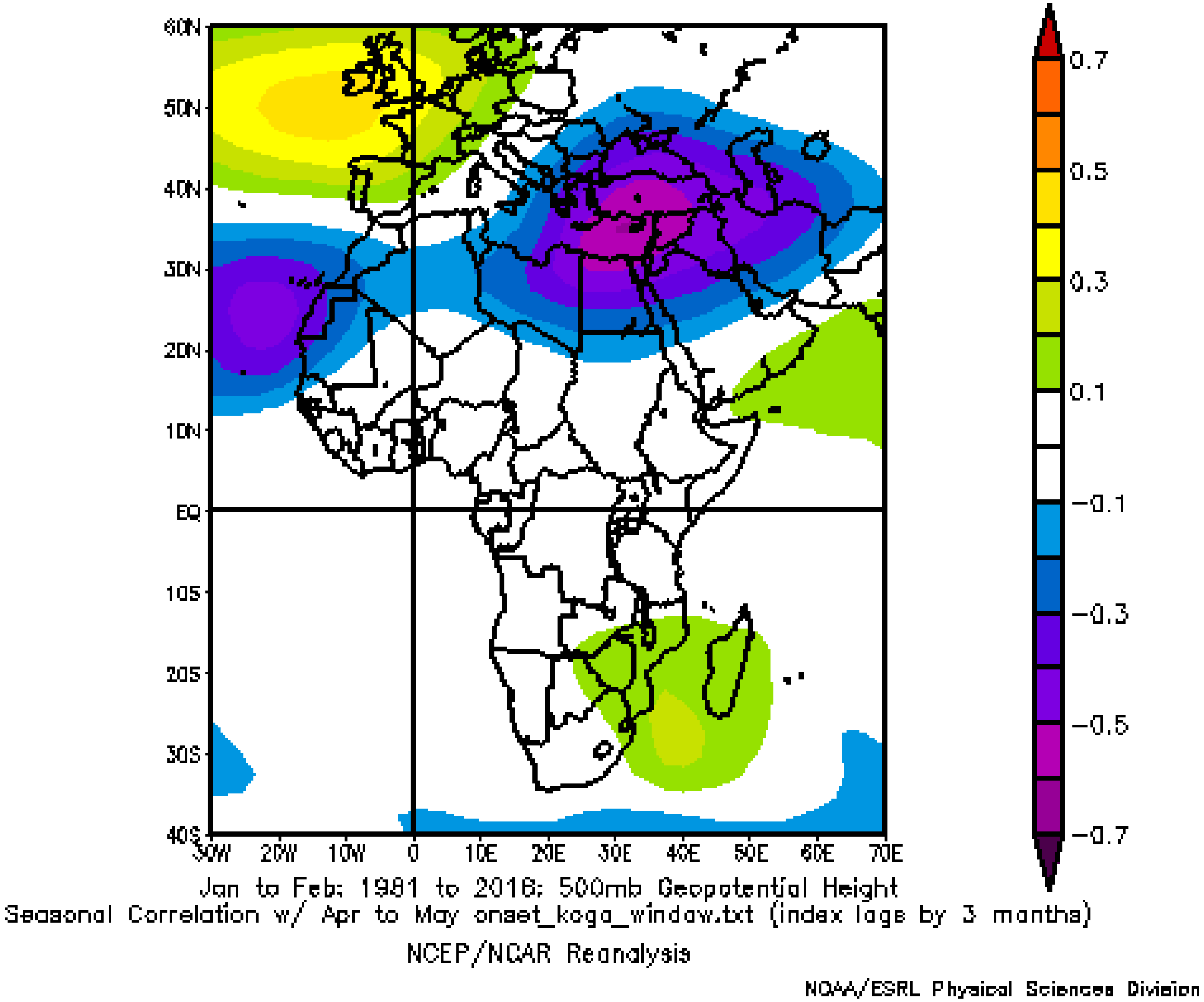


Daily precipitation and cumulative precipitation anomaly, 1981

Defining onset

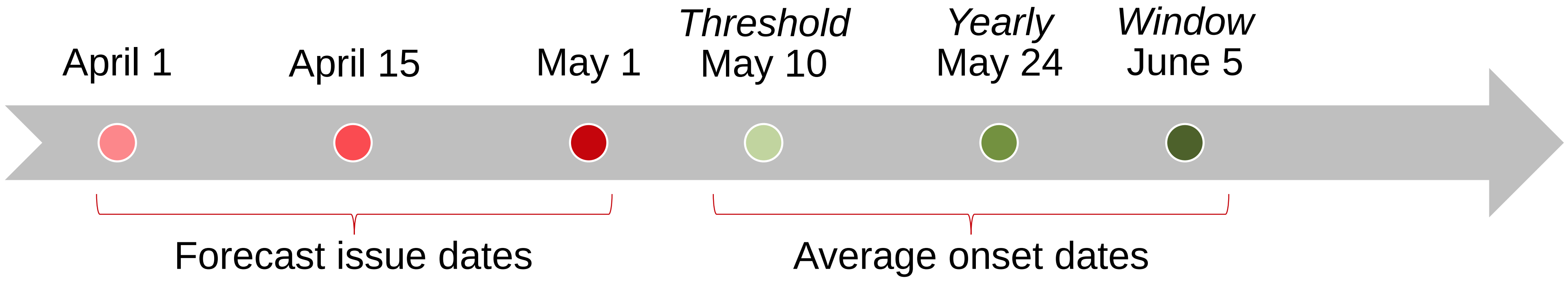


Climate signals



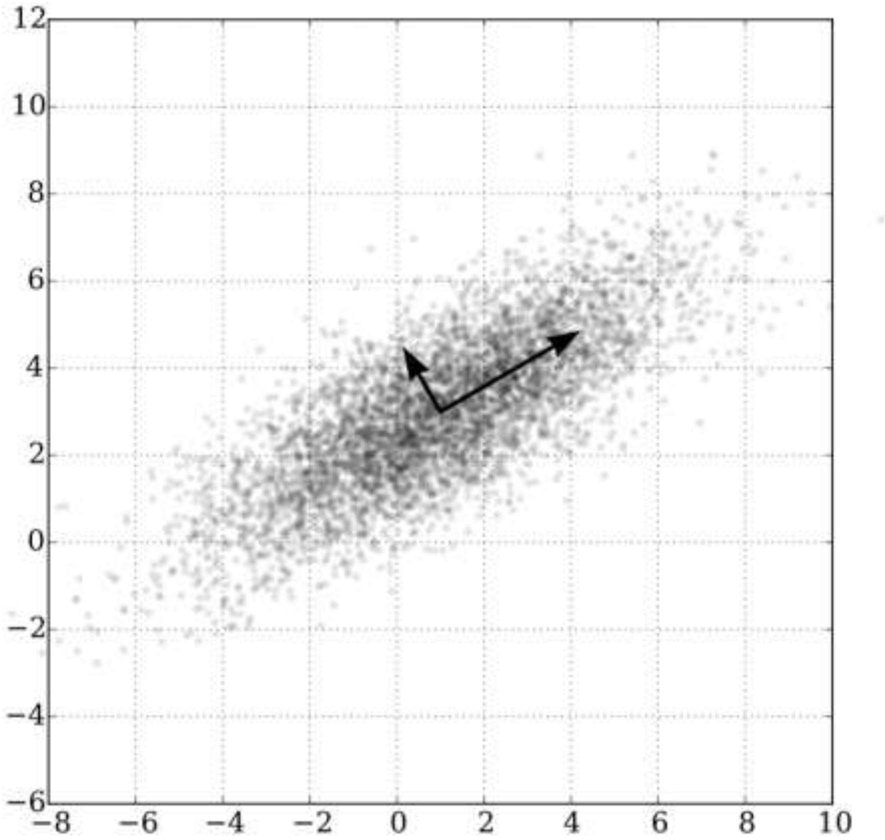
Modeling methods

- Two models
  1. Partial least squares (PLS) regression
     - Date and classification (early/normal/late)
     - Deterministic and probabilistic outputs
  2. Random forest
     - Classification
     - Deterministic
- Three forecast issue dates: April 1, April 15, and May 1



Modeling methods

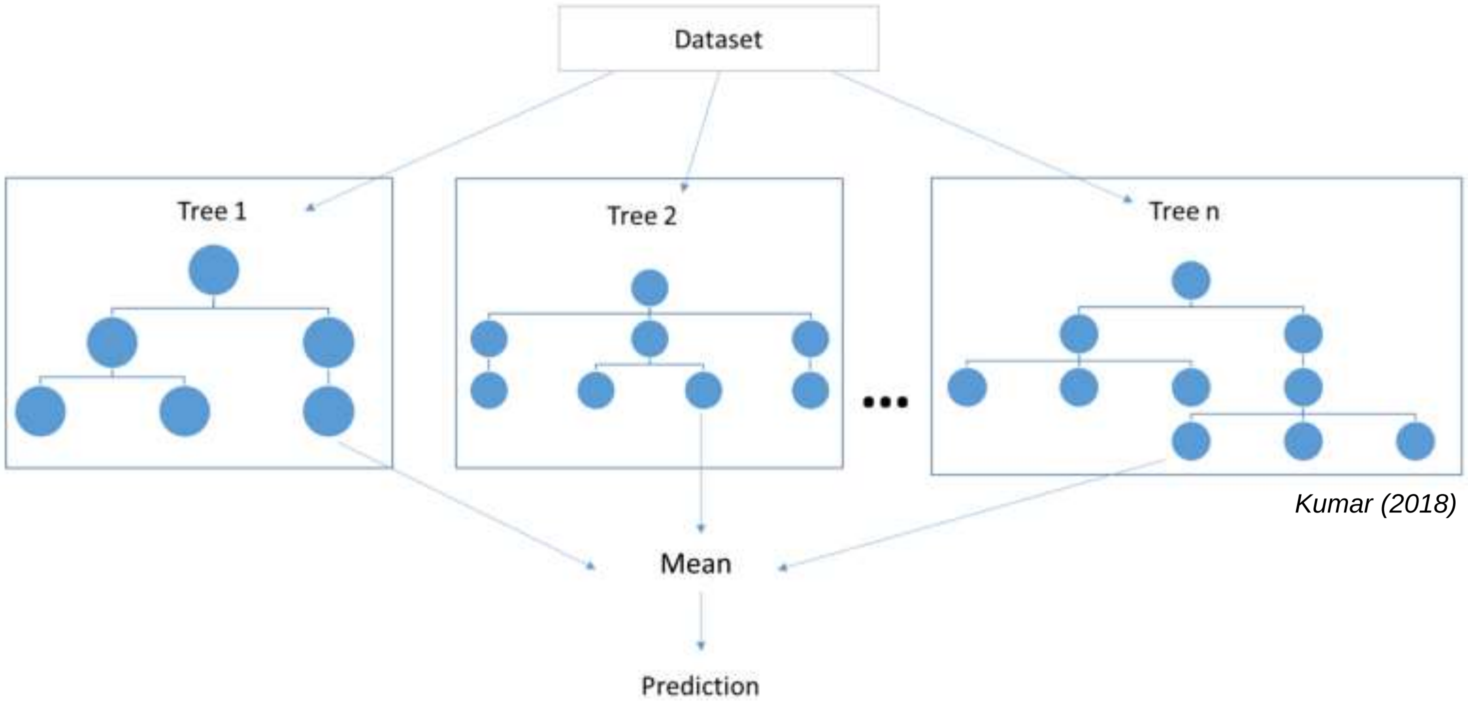
- Partial least squares (PLS) regression
  - Multicollinearity
  - Keep all terms explaining >10% variance
  - One-year cross validation
  - Ensemble using bootstrapped sampling of residuals



Wikipedia

Modeling methods

- Random forest
  - Classification by terciles of historic data (early, normal, late)
  - One-year cross validation
  - Deterministic: no probabilistic information



Kumar (2018)

Results

Results

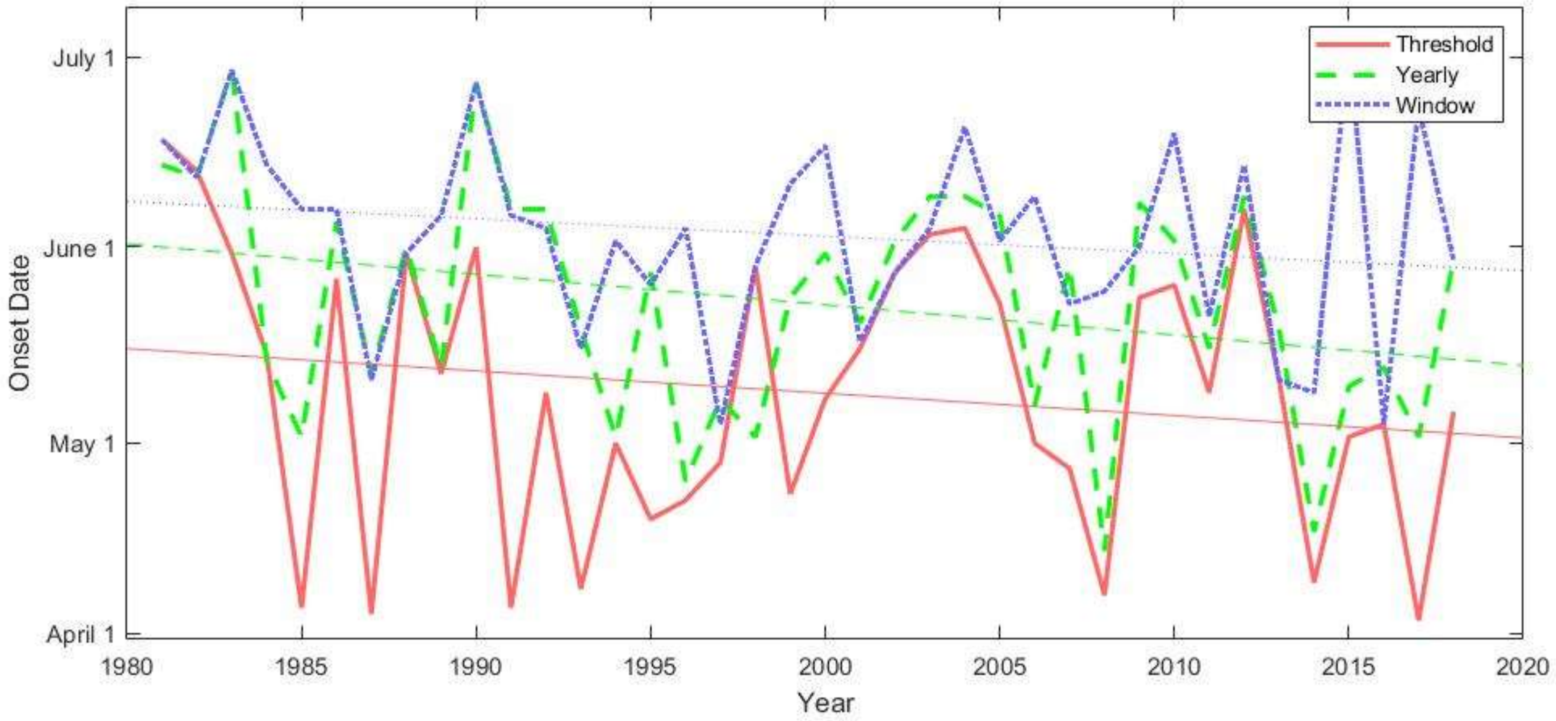
Which climate signals dominate onset of the rainy season?

Definition	Variable	Region	Latitude	Longitude	Month(s)	r
Threshold	SLP	South Pacific *	0-20S	150W-170W	Feb-Mar	-0.346
		North Atlantic	15-30N	20W-50W	Feb-Mar	-0.377
	Geopotential Height	Red Sea (1000 mb)	16-25N	36-43E	Mar	0.434
		Eastern Mediterranean (500 mb) *	30-40N	20-35E	Jan-Feb	-0.325
		Sahara (200 mb)	20-30N	10-30E	Apr	0.420
	Precipitable Water	Sahara / Red Sea	15-20N	35-40E	Apr	-0.431
Window	SST	Mediterannean	30-40N	10-35E	Feb	-0.446
	SLP	Western Pacific	15S-5N	140-175E	Feb	0.439
		Sahara	20-35N	10-40E	Mar	0.459
		North Atlantic	40-55N	20W-5E	Jan-Feb	0.455
	Geopotential Height	Eastern Mediterranean (500 mb)	25-42N	20-40E	Jan-Feb	-0.587
		West African coast (500 mb)	15-30N	10-30W	Jan-Feb	-0.394
Yearly	SLP	Mediterranean / Red Sea *	10-40N	20-45E	Mar	0.517
		North Atlantic	30-50N	0-20W	Jan	0.449
	Geopotential Height	Equatorial Pacific (1000 mb)	20S-5N	105-165W	Mar	-0.479
		Mediterranean / Red Sea (1000 mb)	10-40N	20-45E	Mar	0.525
	Zonal Wind	Sahara (250 mb)	25-35N	5W-20E	Apr	0.588

* only used in April 1 issue date

Results

How does onset vary among seasons and definitions?

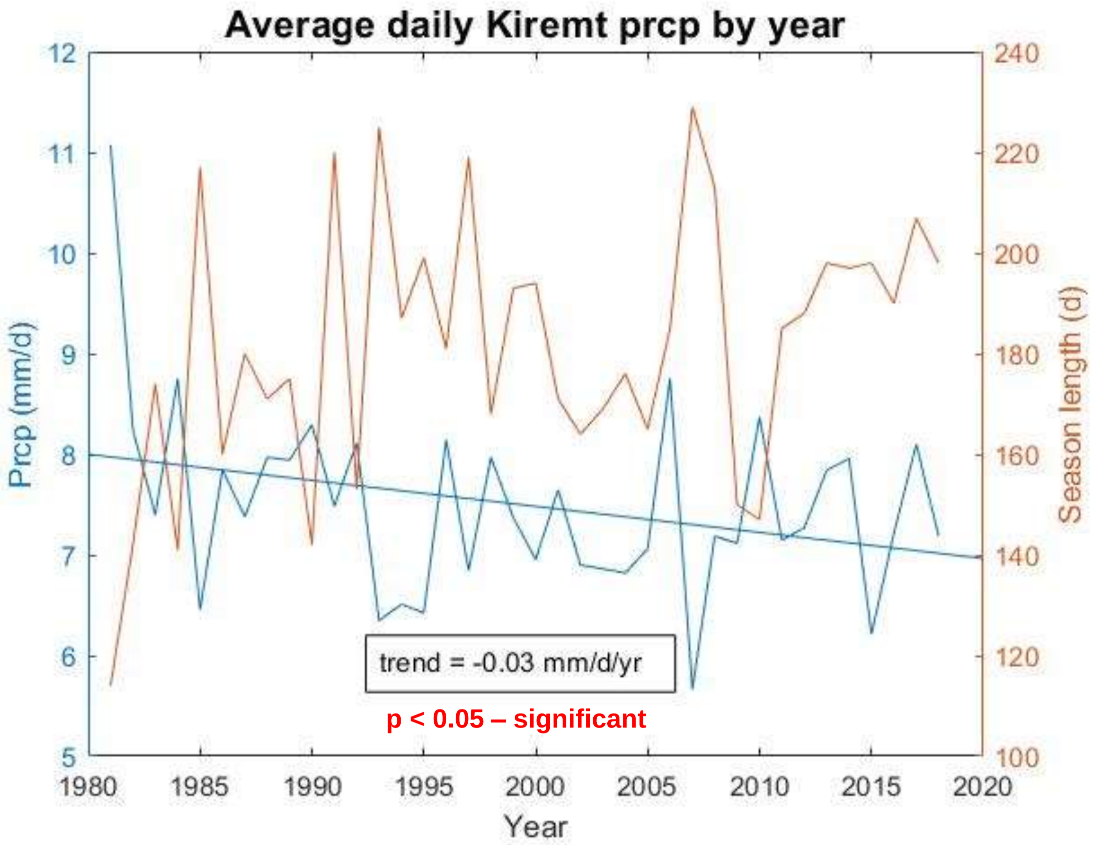


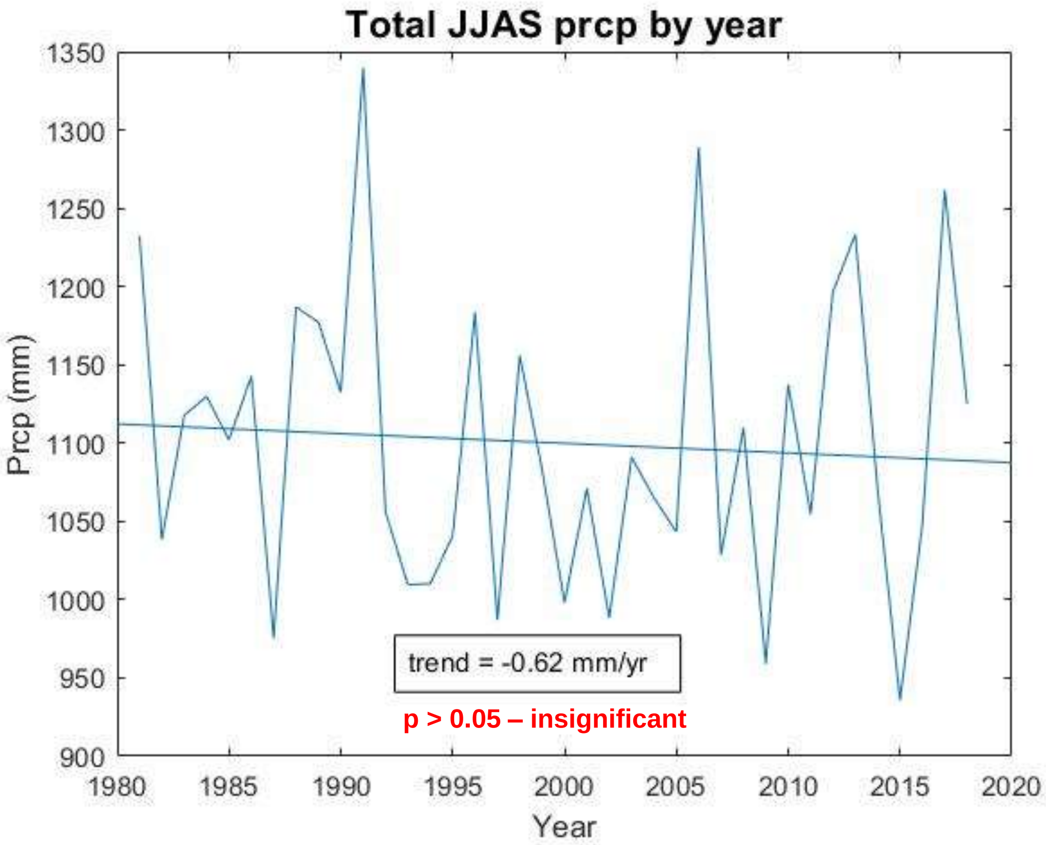
	Threshold	Yearly	Window
Threshold	-	0.64	0.39
Yearly	15.9	-	0.48
Window	26.0	15.3	-

Correlations (above diagonal), mean absolute difference (days, below diagonal)

Results

How does onset connect to other characteristics of the rainy season?



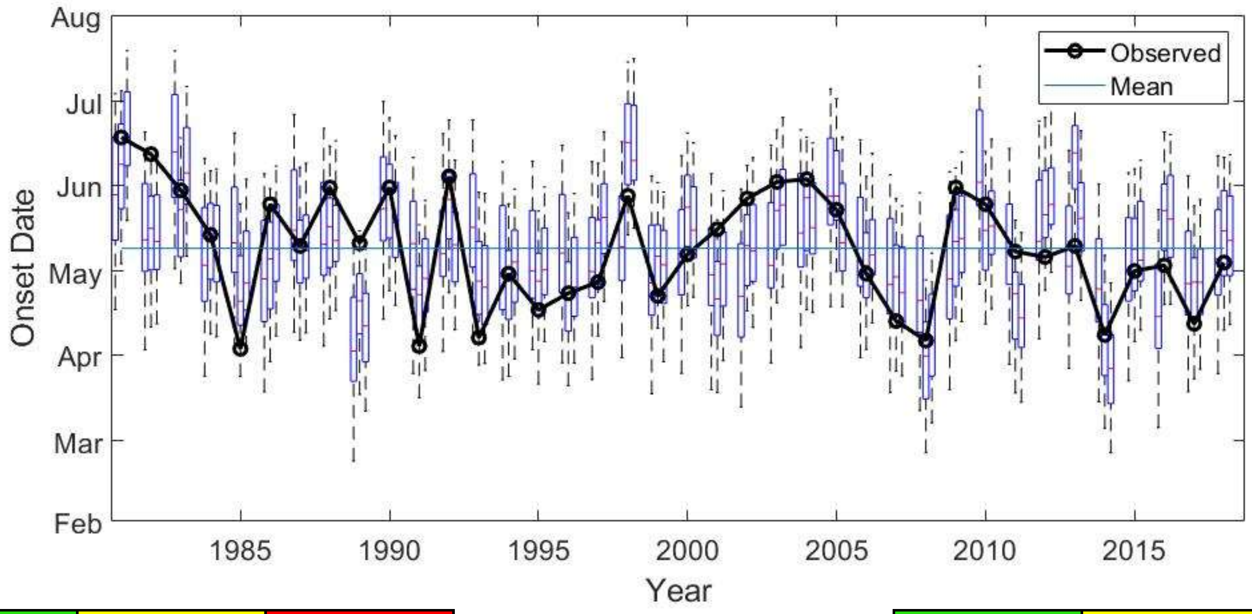


Results

Can statistical forecasts of onset demonstrate skill?

		April 1			April 15				May 1			
	Average climatology error (d)	Average prediction error (d)	% Reduction in error	Median RPSS	Average prediction error (d)	% Reduction in error	Median RPSS	% Onsets missed	Average prediction error (d)	% Reduction in error	Median RPSS	% Onsets missed
Threshold	17.5	15.3	12%	11%	12.2	30%	44%	18%	12.7	27%	38%	29%
Yearly	16.4	13.3	19%	39%	12.8	22%	33%	3%	11.4	30%	44%	8%
Window	15.4	11.4	26%	44%	-	-	-	-	-	-	-	-

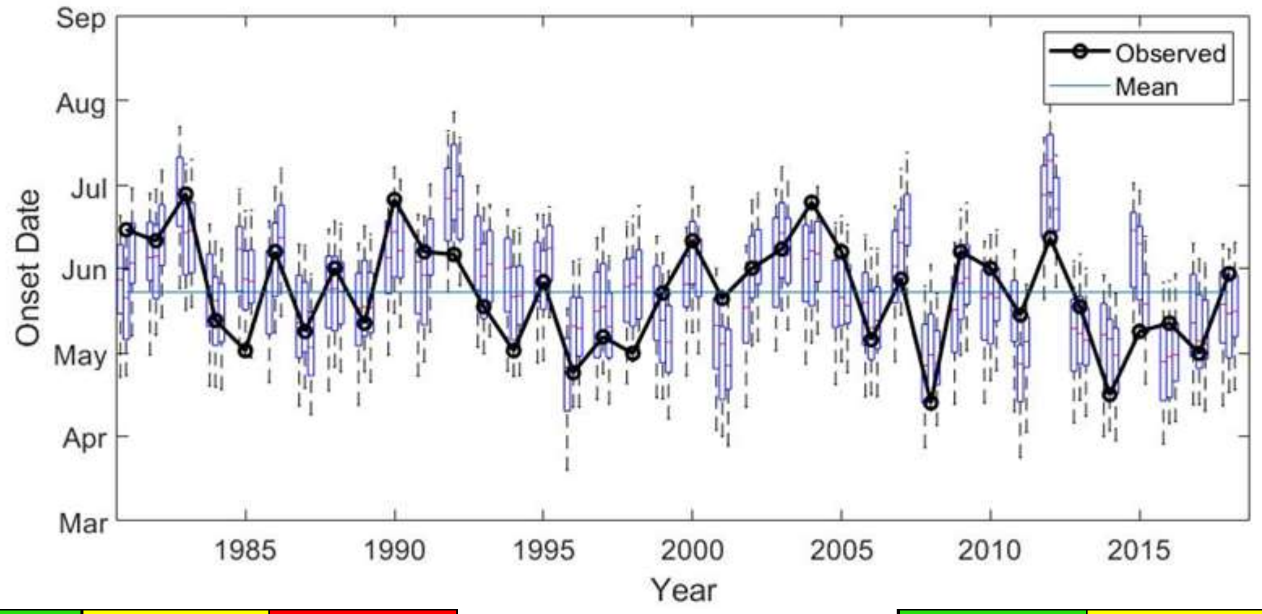
Results – Threshold definition



Forecast	Observation: Early	Observation: Normal	Observation: Late	
Early	13% 24% 24%	5% 5% 5%	3% 3% 0%	← April 1 ← April 15 ← May 1
Normal	21% 11% 11%	24% 24% 24%	24% 18% 24%	
Late	0% 0% 0%	3% 3% 3%	8% 13% 11%	

Forecast	Observation: Early	Observation: Normal	Observation: Late
Early	21% 26% 21%	13% 8% 8%	11% 8% 3%
Normal	5% 5% 13%	3% 8% 11%	8% 16% 16%
Late	8% 3% 0%	16% 16% 13%	16% 11% 16%

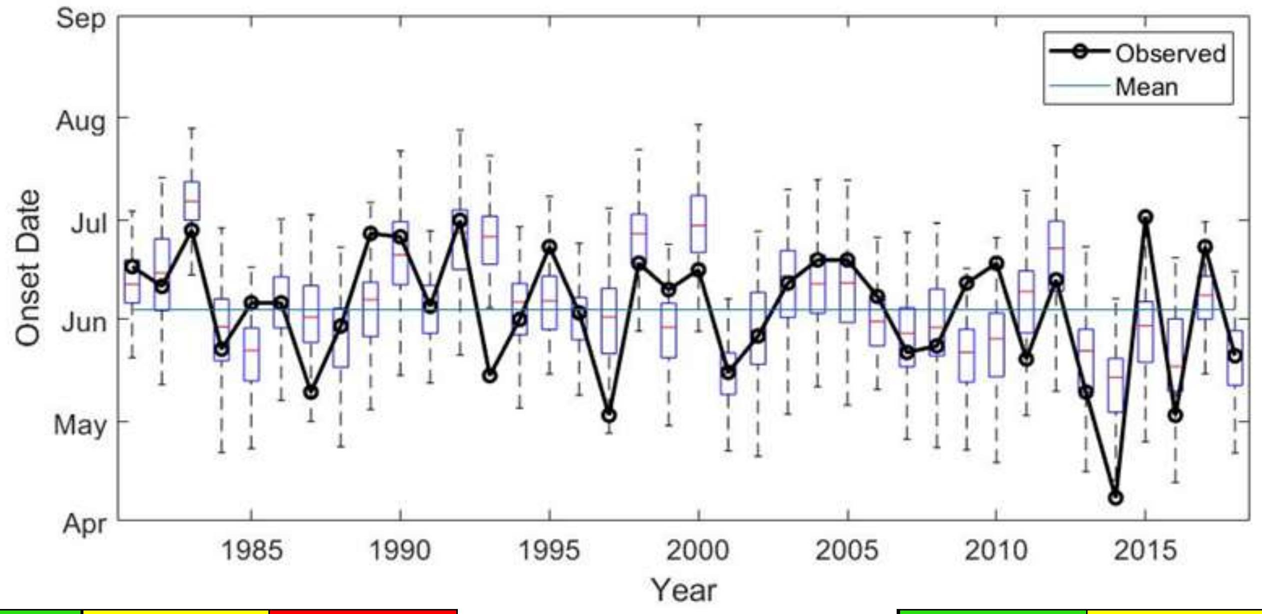
Results – Yearly definition



Forecast	Observation: Early	Observation: Normal	Observation: Late	
Early	8%	8%	3%	← April 1
	11%	13%	0%	← April 15
	16%	11%	0%	← May 1
Normal	26%	24%	21%	
	24%	16%	21%	
	18%	16%	13%	
Late	0%	0%	11%	
	0%	3%	13%	
	0%	5%	21%	

Forecast	Observation: Early	Observation: Normal	Observation: Late
Early	8%	13%	8%
	11%	16%	5%
	13%	13%	3%
Normal	13%	8%	8%
	18%	8%	5%
	16%	8%	8%
Late	13%	11%	18%
	5%	8%	24%
	5%	11%	24%

Results – Window definition



Forecast \ Observation	Early	Normal	Late
Early	**21%**	**5%**	**3%**
Normal	**11%**	**24%**	**18%**
Late	**3%**	**3%**	**13%**

← April 1

Forecast \ Observation	Early	Normal	Late
Early	**21%**	**8%**	**5%**
Normal	**11%**	**16%**	**5%**
Late	**3%**	**8%**	**24%**

Conclusion

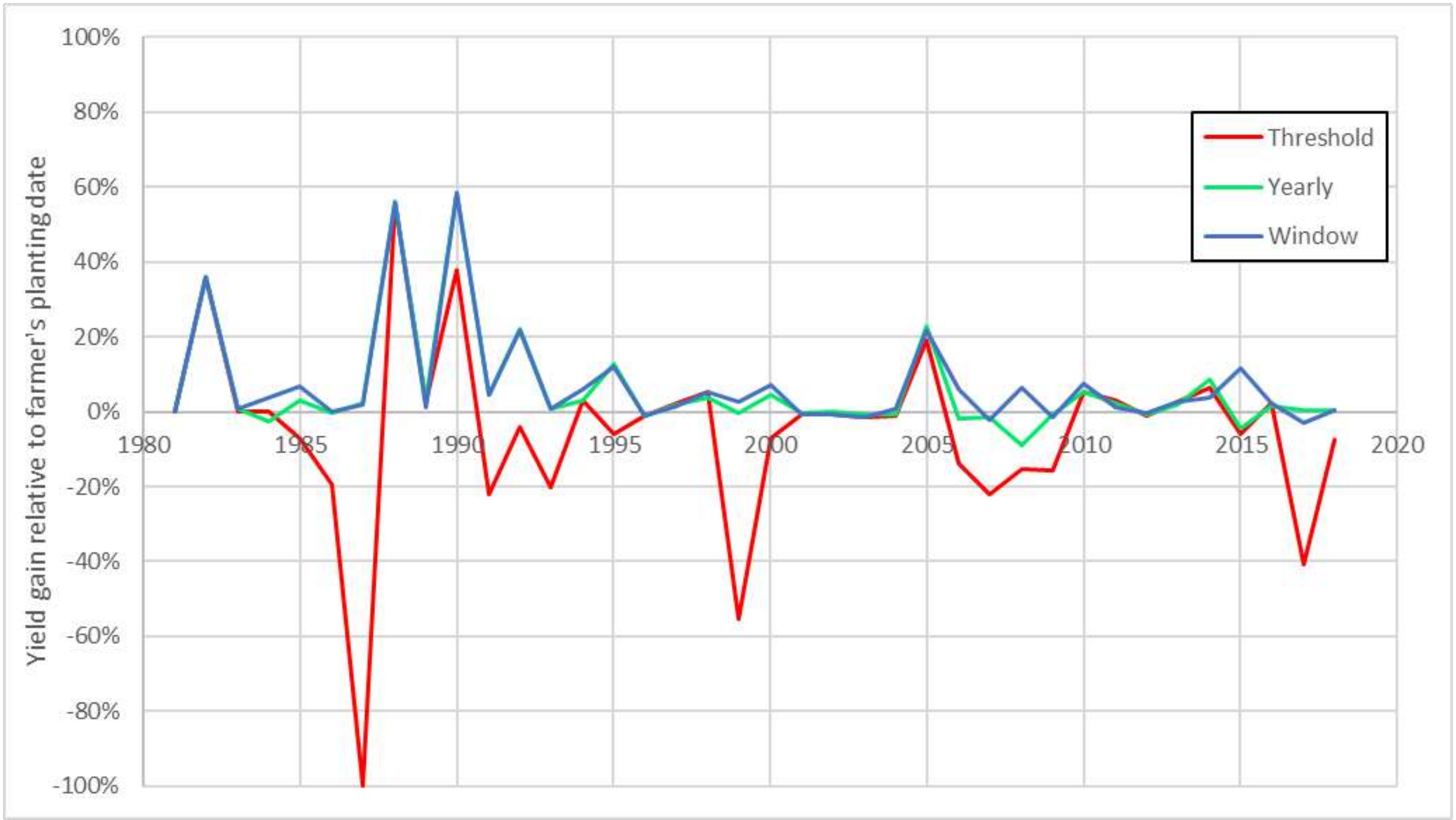
- Onset is a sensitive concept, cannot be usefully defined or modeled in a single way
  - April 1 window method balances skill and lead time
- Trend of increasingly early onset, with no trend in seasonal precipitation
- Dynamic model comparison (ECMWF)
  - Similar skill
  - Finer spatial resolution (0.05° vs. 0.25°)
  - Shorter lead time (~1 month vs. 3-4 months)

Ongoing work

How can we use predictions to guide decision making?

Maize planting, “farmer’s criteria”: earlier of…

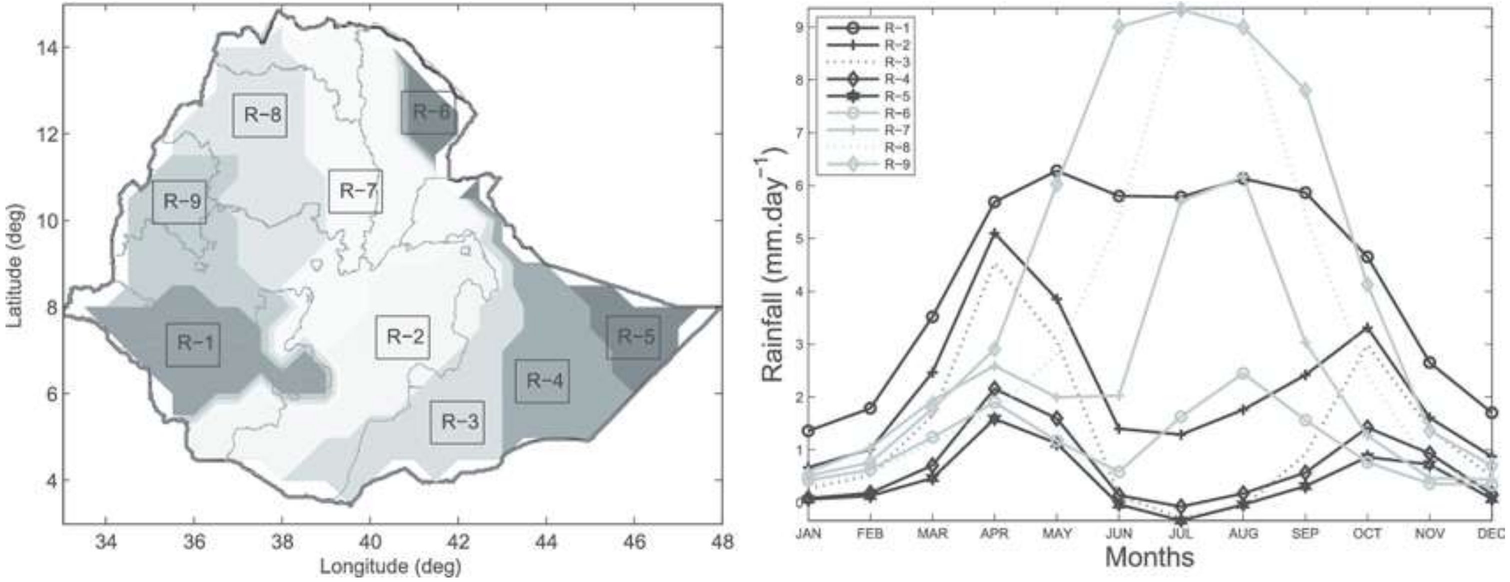
- 50 mm in four days + at least one rainy day in next three days, after April 1
- 20 mm in three days, after May 1



Ongoing work

What are potential large-scale impacts of forecast utilization?

- Ethiopia Economy-wide Multimarket Model (EMM)
  - Add seasonality, investigate forecastable characteristics
  - How can the use of onset or TSP forecasts impact the overall economy?



The homogeneous rainfall regimes determined from the new dataset based on the self-organizing map and (right) their seasonal rainfall variation. (Mengistu Tsidu 2012)

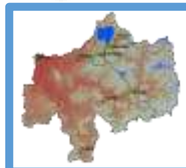
Questions?

PIRE: Water and Food Security in Ethiopia

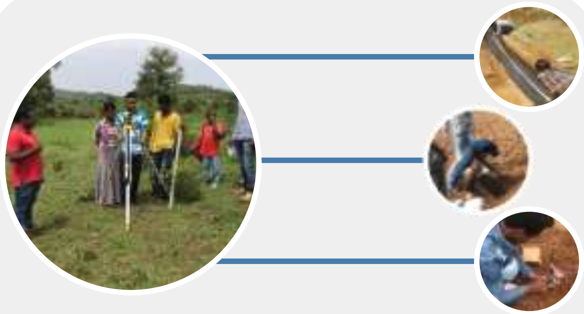
An Overview of the Model Integration to produce the Seasonal Forecast Bulletins

Model Integration for **Dry Season**

Seasonal Forecasts (**NOAA**): precipitation and meteorological variables



Watershed Model (**CREST**)



Citizen Science Data

- **Flow in rivers**
- **Infiltration**

Groundwater Model **(MODFLOW-NWT)**

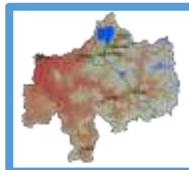
- **Groundwater levels**
- **Soil moisture**

Crop Yield Model (**DSSAT**)

- **Crop Yields**

Model Integration for **Wet Season**

Seasonal Forecasts (**NOAA**): precipitation and meteorological variables



Watershed Model (**CREST**)

Analogue Model

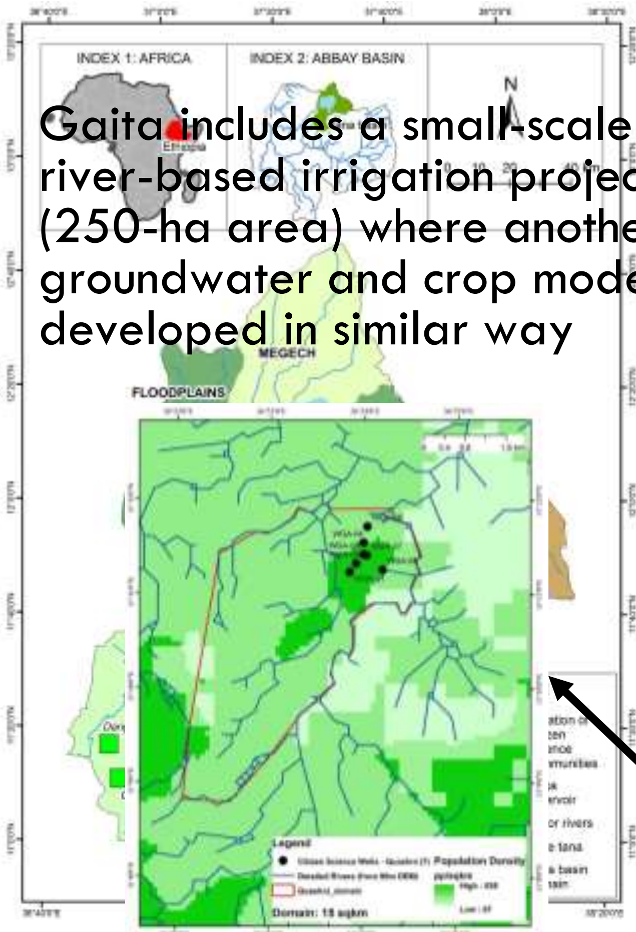
- Initial Soil Moisture Conditions

- Provide Analogue Years

Crop Yield Model (**DSSAT**)

- Crop Yields

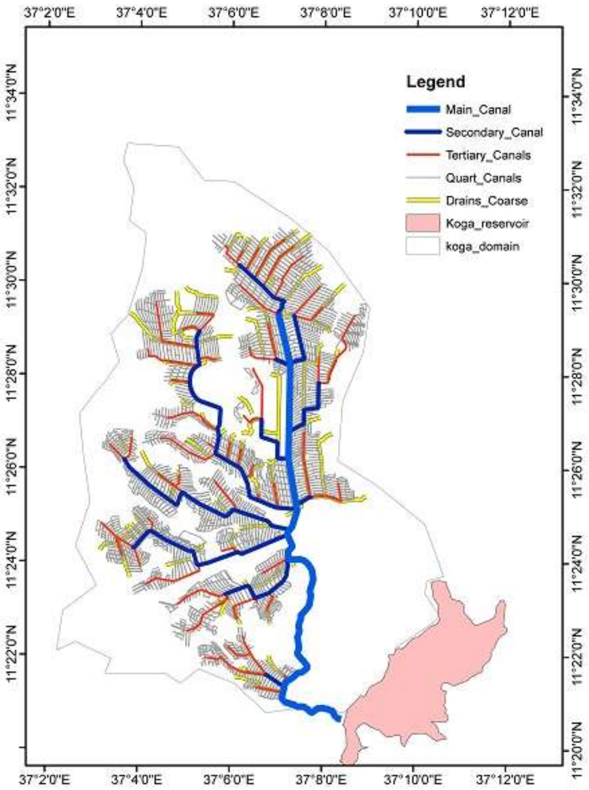
Spatial scale of the Forecast



Gaita includes a small-scale river-based irrigation project (250-ha area) where another groundwater and crop model is developed in similar way

Seasonal forecast for dry season is focused in **Two irrigated sites (Kudmi and Gaita)**

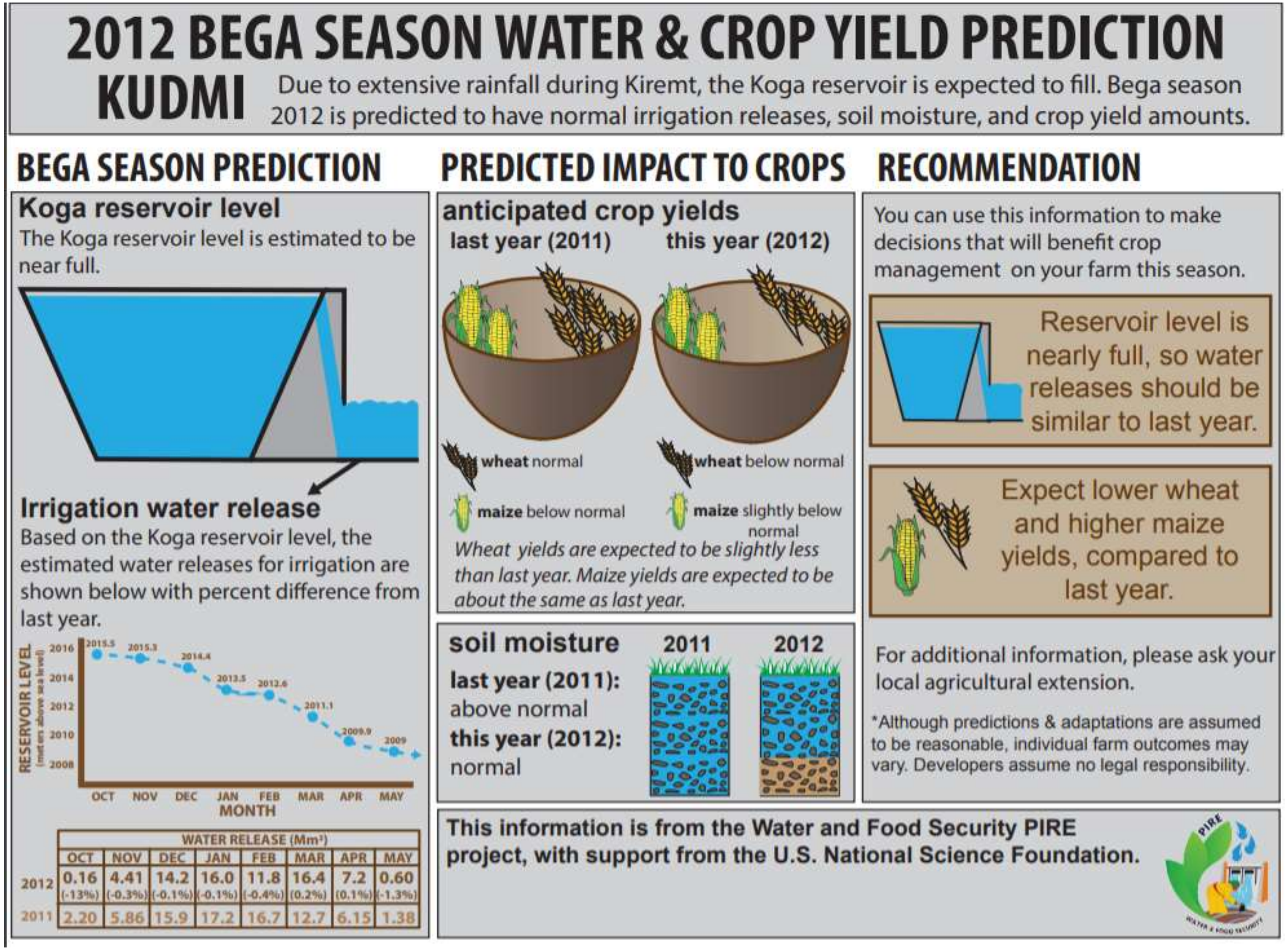
Kudmi includes 7000-ha large **Koga irrigation project** where intensive groundwater and crop models are simulated to produce Soil moisture and Crop yield



Seasonal forecast for the wet season is provided for **four target communities (highlighted in green squares), of which two (in Gaita) and two irrigated**

Quashni Irrigation Area

The Forecast Bulletin (Dry Season)



2012 BEGA SEASON WATER & CROP YIELD PREDICTION

KUDMI

Due to extensive rainfall during Kiremt, the Koga reservoir is expected to fill. Bega season 2012 is predicted to have normal irrigation releases, soil moisture, and crop yield amounts.

BEGA SEASON PREDICTION

Koga reservoir level

The Koga reservoir level is estimated to be near full.

Irrigation water release

Based on the Koga reservoir level, the estimated water releases for irrigation are shown below with percent difference from last year.

	WATER RELEASE (Mm³)							
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
2012	0.16 (-13%)	4.41 (-0.3%)	14.2 (-0.1%)	16.0 (-0.1%)	11.8 (-0.4%)	16.4 (0.2%)	7.2 (0.1%)	0.60 (-1.3%)
2011	2.20	5.86	15.9	17.2	16.7	12.7	6.15	1.38

PREDICTED IMPACT TO CROPS

anticipated crop yields

last year (2011): **wheat** normal; **maize** below normal

this year (2012): **wheat** below normal; **maize** slightly below normal

Wheat yields are expected to be slightly less than last year. Maize yields are expected to be about the same as last year.

soil moisture (2011, 2012)

last year (2011): above normal

this year (2012): normal

RECOMMENDATION

You can use this information to make decisions that will benefit crop management on your farm this season.

Reservoir level is nearly full, so water releases should be similar to last year.

Expect lower wheat and higher maize yields, compared to last year.

For additional information, please ask your local agricultural extension.

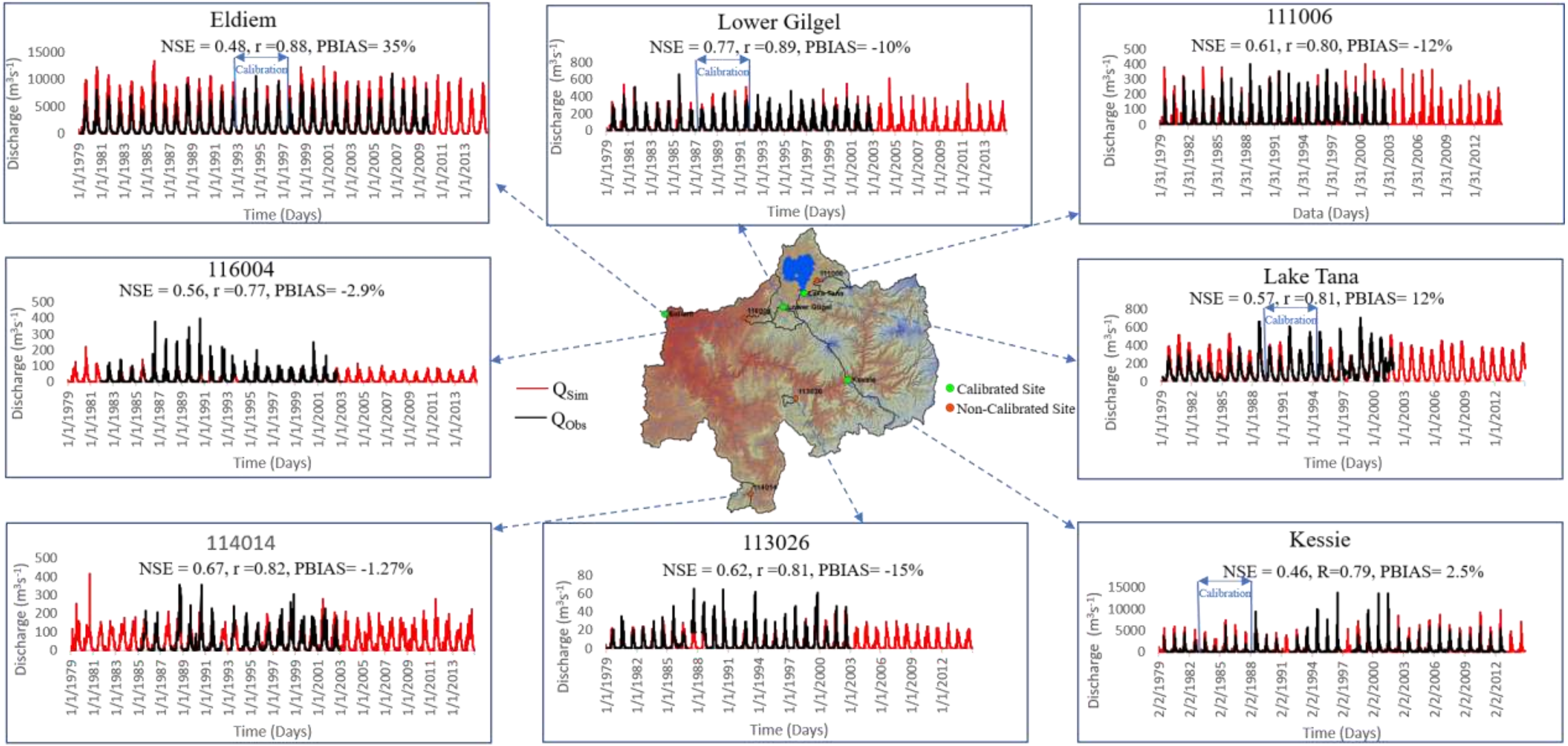
*Although predictions & adaptations are assumed to be reasonable, individual farm outcomes may vary. Developers assume no legal responsibility.

This information is from the Water and Food Security PIRE project, with support from the U.S. National Science Foundation.

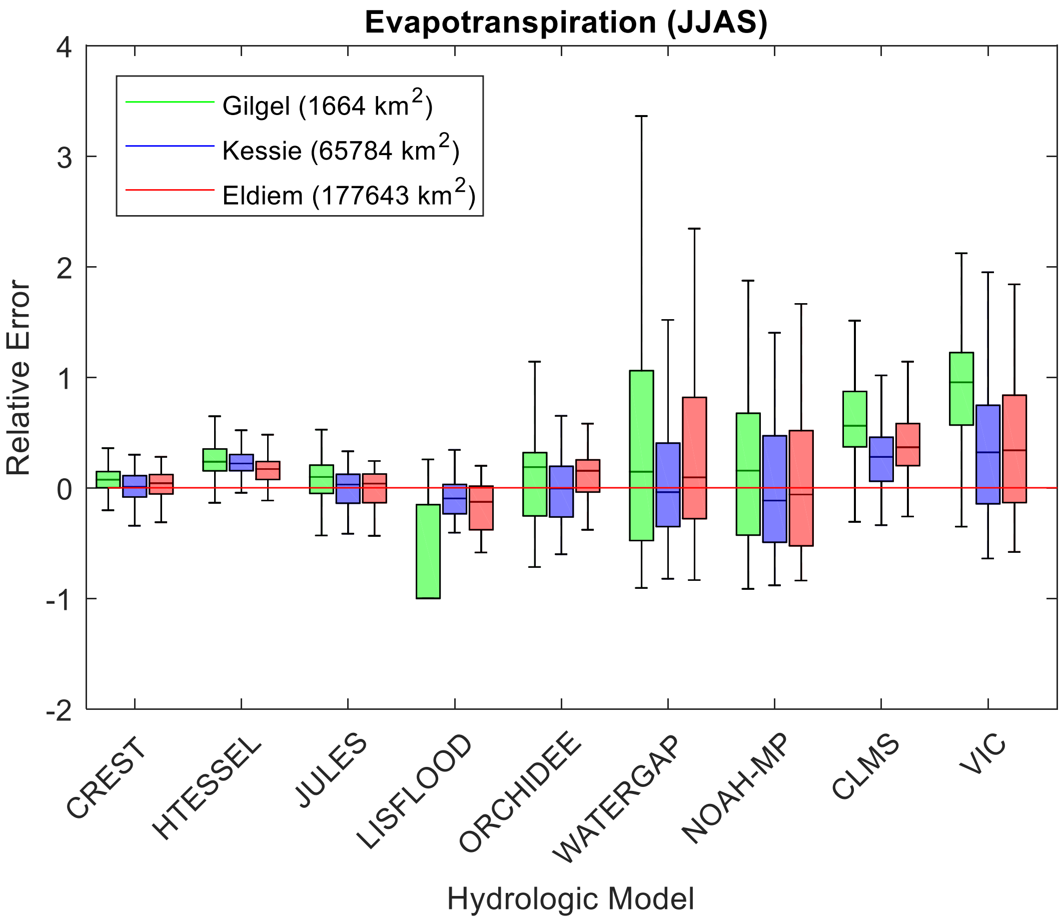
The bulletin is provided to the Social Science team who have resources in field level to disseminate the information to both Water Managers and Farmers

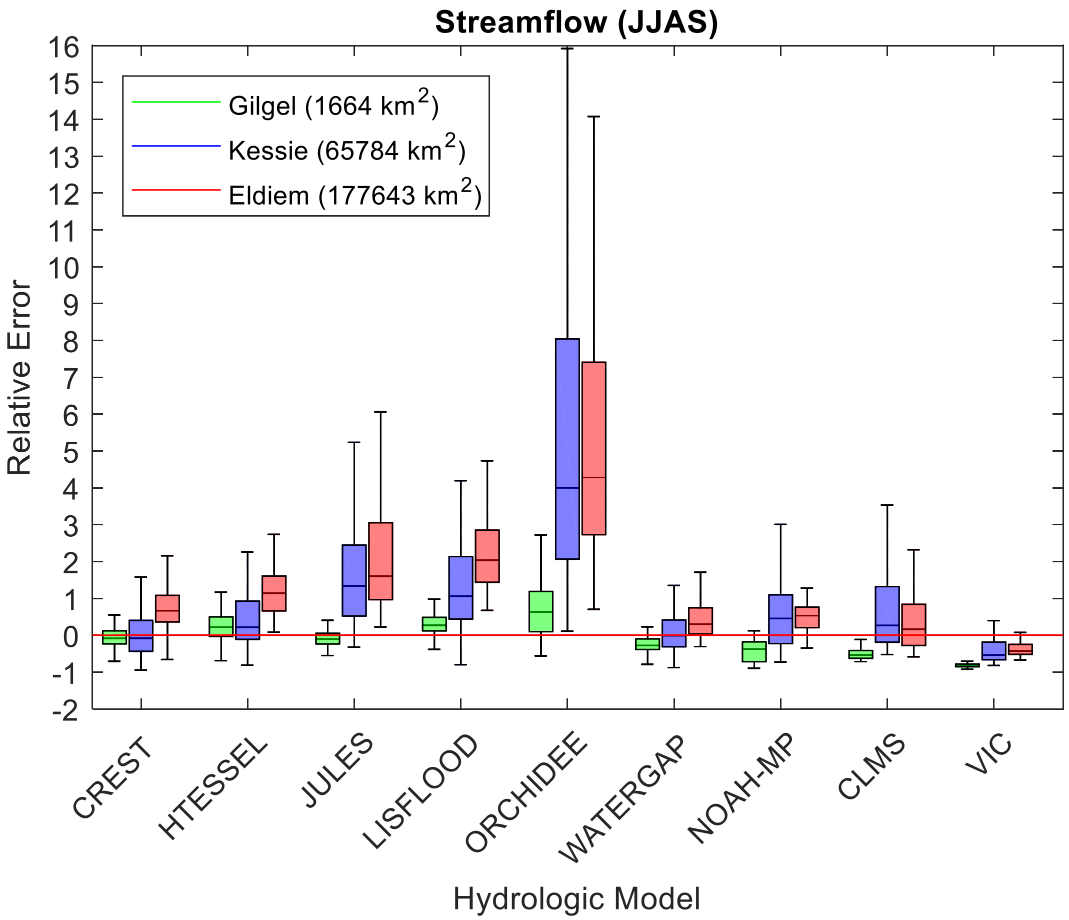
Along with the bulletin, a one-page companion document is provided to support supplementary information on modelling details

Hydrological Model (CREST) Evaluation in Different Regions



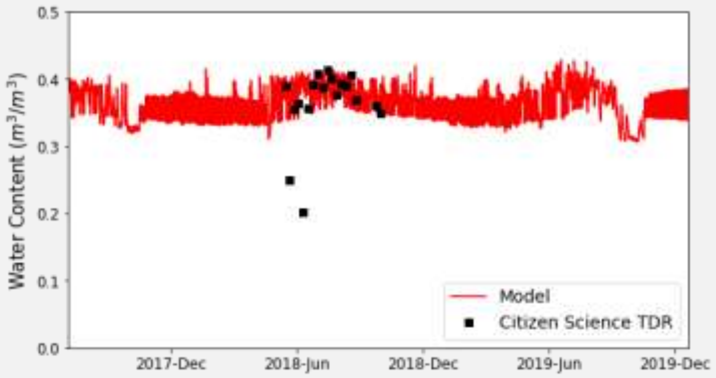
Multi-Model Comparison of ET & Streamflow (CREST)



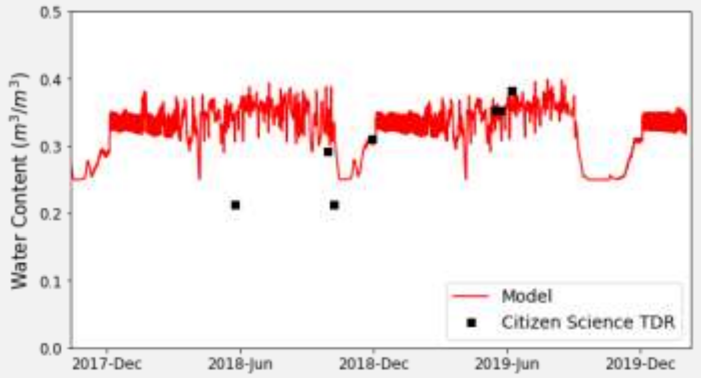


GW Model Evaluation using Citizen Science at 2 communities

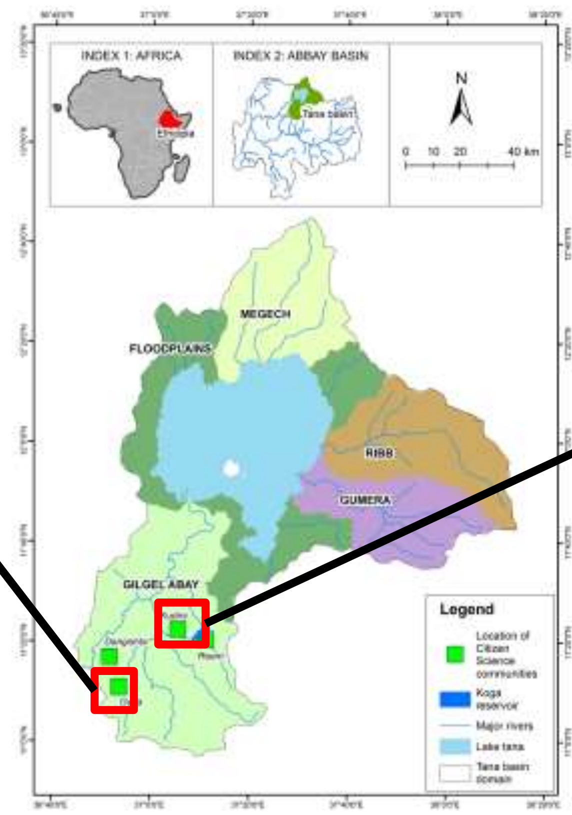
Soil Moisture



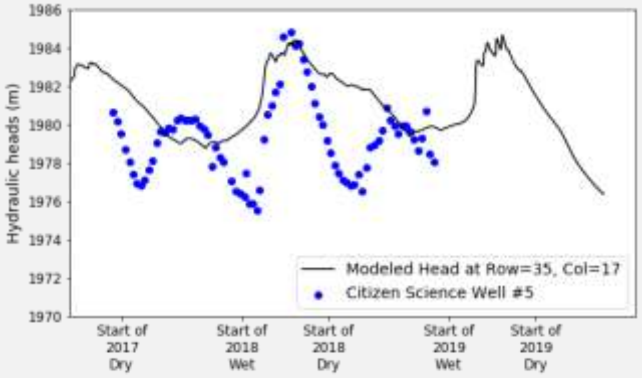
SITE: KUDMI



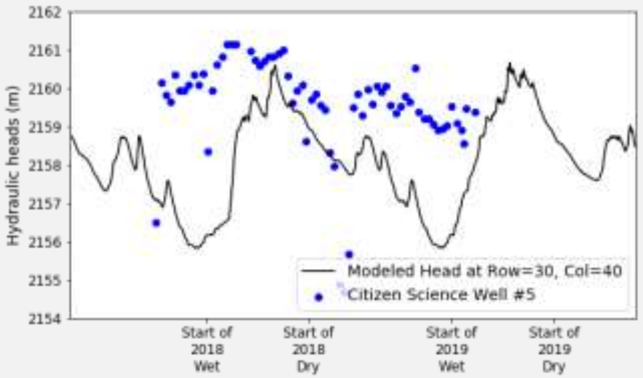
SITE: GAITA



Groundwater Table Depth



SITE: KUDMI



SITE: GAITA

PRECIPITATION FORECAST

prediction of total Kiremt season rainfall

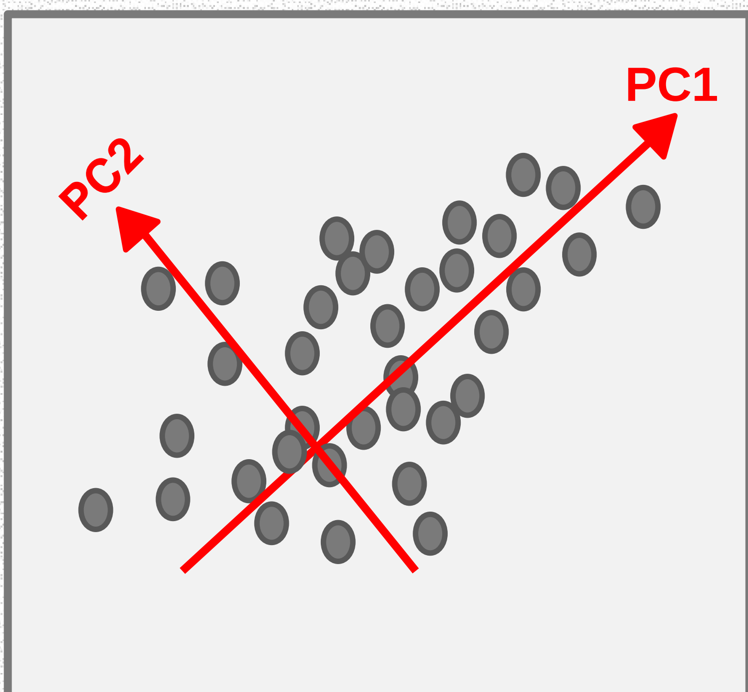
Sarah Alexander

PIRE Annual Meeting

November 20, 2019

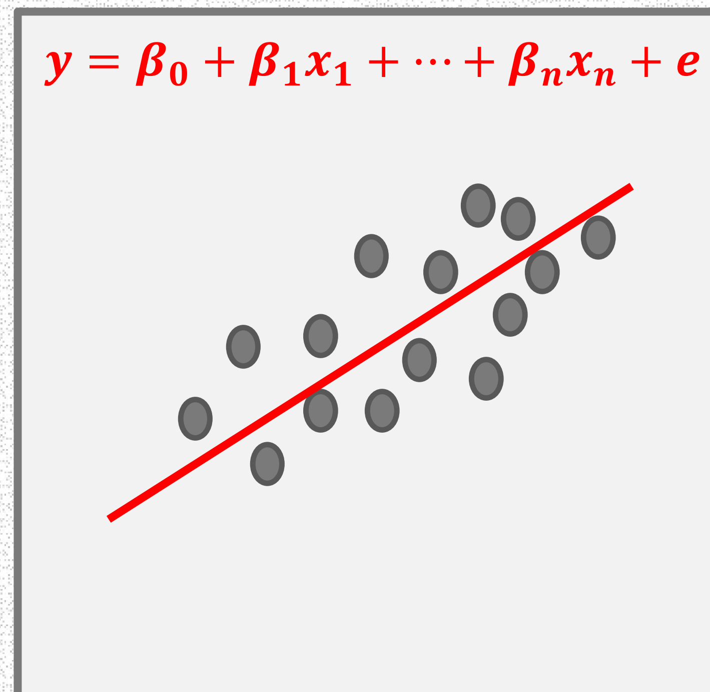
WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Statistical Prediction Framework



Principal Component Analysis

+



Multiple Linear Regression

Principle Component Regression (PCR)

Top PCs of potential predictors retained for MLR input

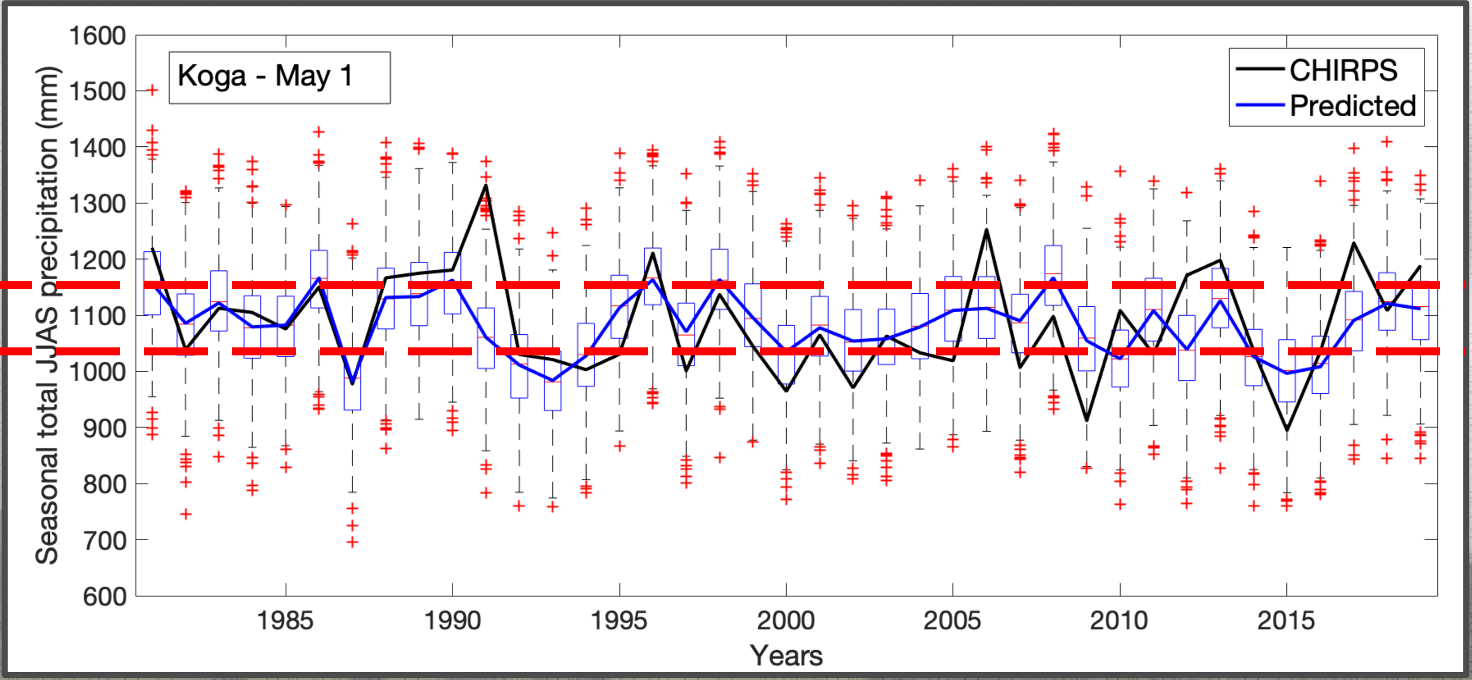
Leave-one-year-out cross-validation, error distribution used to form ensembles

Hindcast prediction of JJAS precipitation

Above

Normal

Below



	OBSERVED		
PREDICTED	***Below***	***Normal***	***Above***
Below	8	3	1
Normal	4	7	2
Above	0	3	11

Categorical information may be valuable

Hindcast prediction of JJAS precipitation

Forecast performs best for May 1 lead time, with significant drop in skill for the spring (Apr 1) forecasts

Region	Issue date	Pearson Corr.	RPSS (%)	Hit Score (%)	Extreme Miss score (%)
Koga	1 Jan	0.52	27	57	11
	1 Apr	0.13	-3.4	27	19
	1 May	**0.56**	**22**	**38**	**0**

Deterministic: Pearson correlation

Rank Probability Skill Score (RPSS): > 0, more skill than climatology

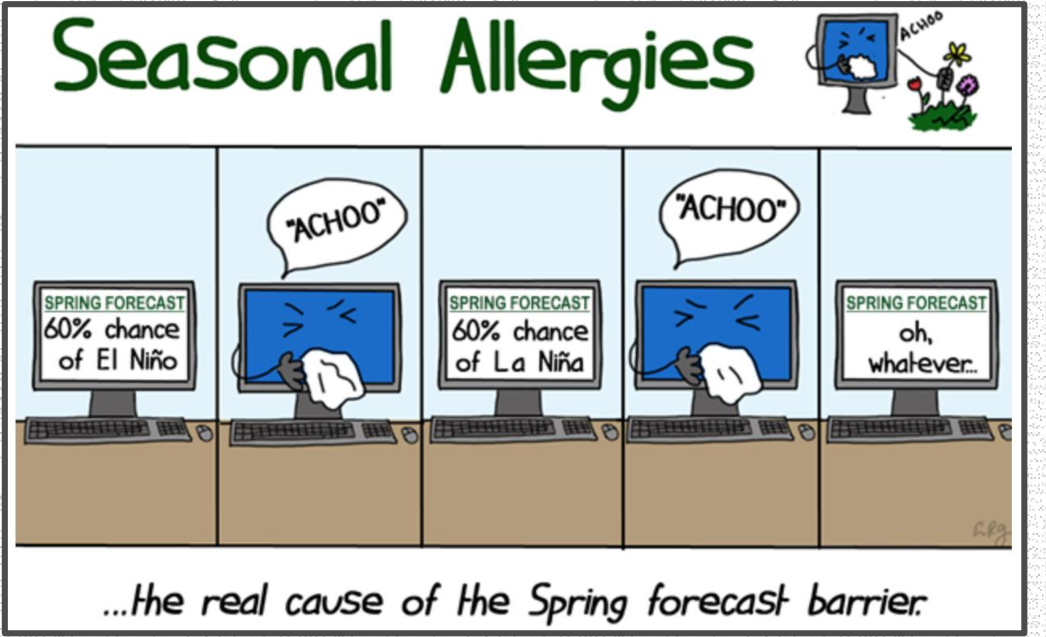
Hit Score: % years categorically correct (100 = perfect forecast)

Extreme Miss Score: % years off by 2 categories (0 = good forecast)

Prediction lead time and skill

Spring barrier:

- Transitional time for ENSO (signal low, noise high)
- Weaker sea-surface temperature gradients
- "Lull" in forecast accuracy



Source: NOAA

PIRE Forecasts issued: February? March? April? May?

A trade-off exists between prediction skill and lead time to provide valuable predictions to end-users

How can predictions inform end-user decisions?

seeds, crop type

timing

preparation of land

When is information valuable for farmers?

- What decisions might a forecast be able to inform?
- When do farmers make these decisions?
- What is the optimal timing from a farmer/end-user perspective?

RESERVOIR VOLUME FORECAST

prediction of October Koga reservoir volume

Sarah Alexander

PIRE Annual Meeting

November 20, 2019

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Predicting Koga reservoir level

Probabilistic precipitation predictions →

Relationship between precipitation and reservoir volume

⇓

Water balance to determine inflow:

$$V(t) = V(t-1) + P(t) * SA(t) - ET(t) * SA(t) + I(t) - R(t)$$

Inflow – precipitation relationship:

$$I_{JJAS} = C_1 * (P_{JJAS} - ET_{JJAS}) - C_2$$

Predicting Koga reservoir level

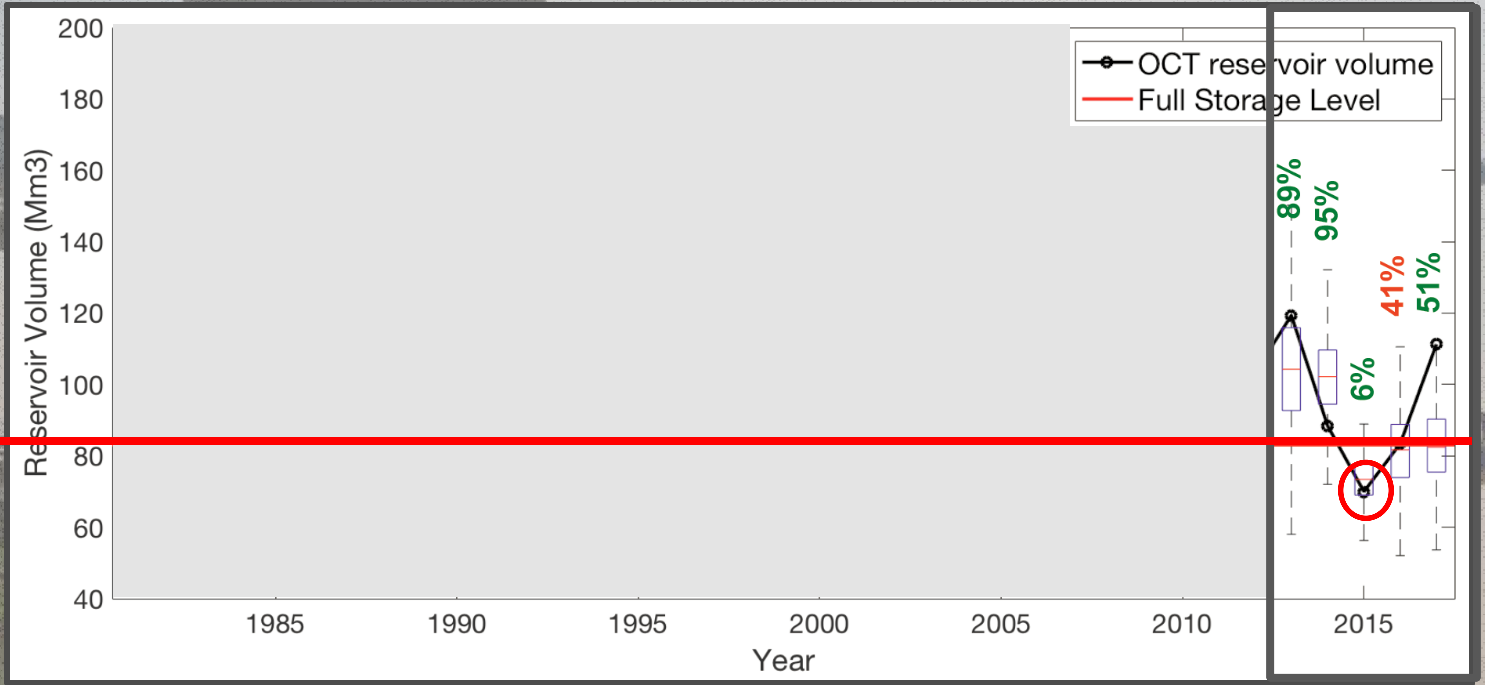
Probabilistic precipitation predictions → Relationship between precipitation and reservoir volume

Predicting Koga reservoir level

June 1 prediction of whether reservoir will fill by end of JJAS season

Reservoir fills

Does not fill

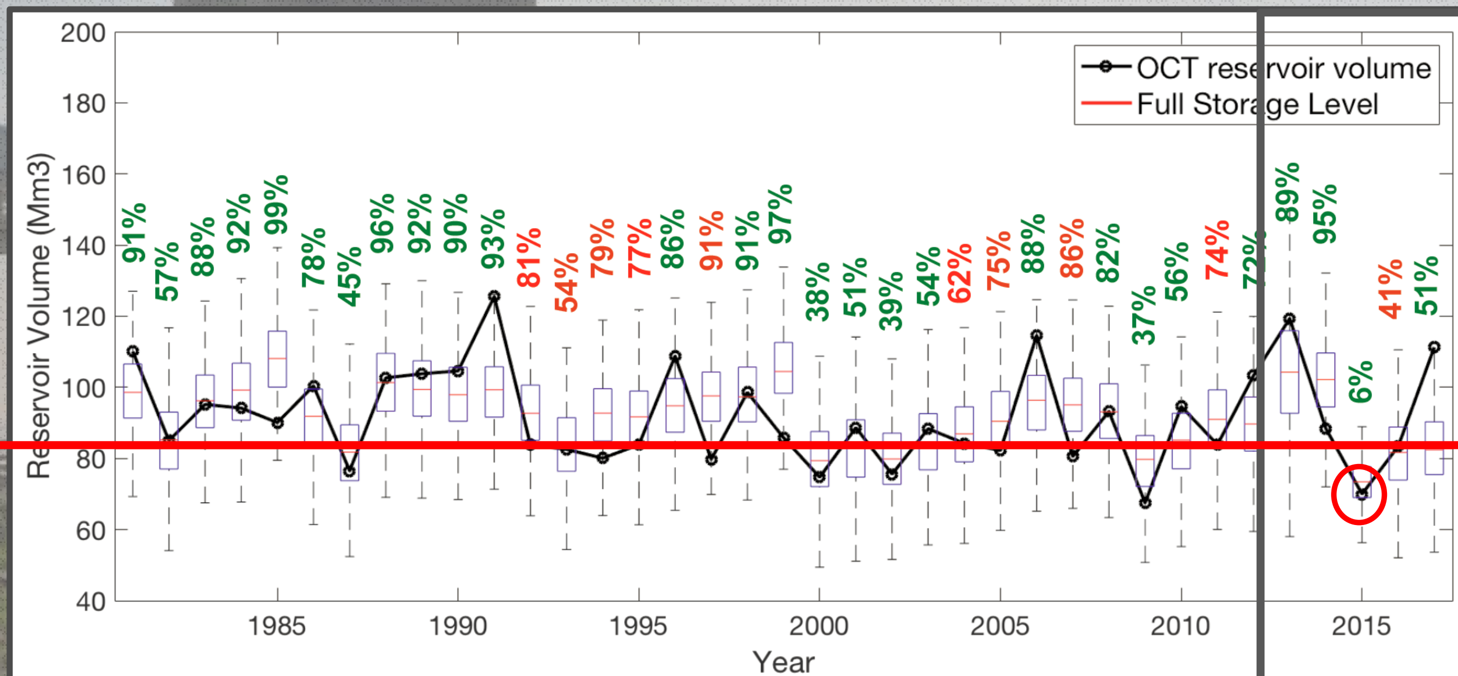


Predicting Koga reservoir level

1/6 years the reservoir may not fill

Reservoir fills

Does not fill

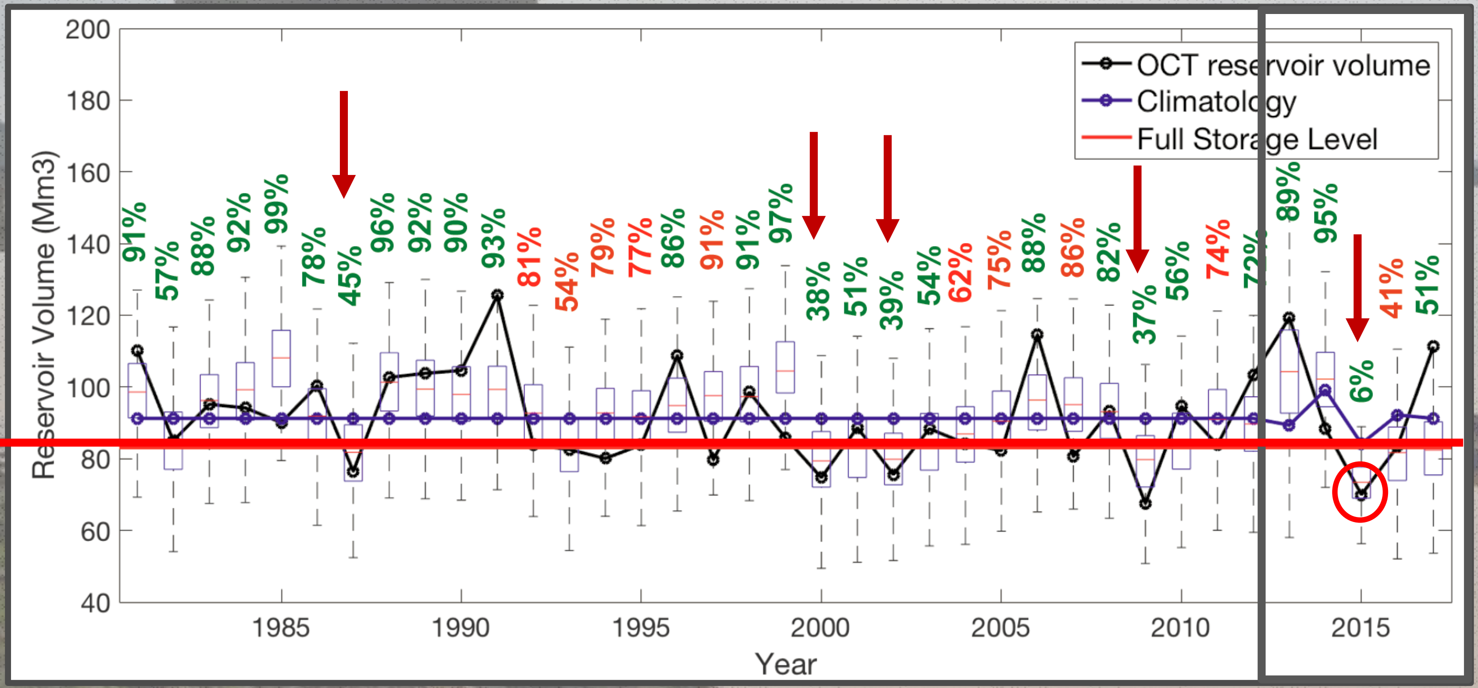


Predicting Koga reservoir level

1/6 years the reservoir may not fill

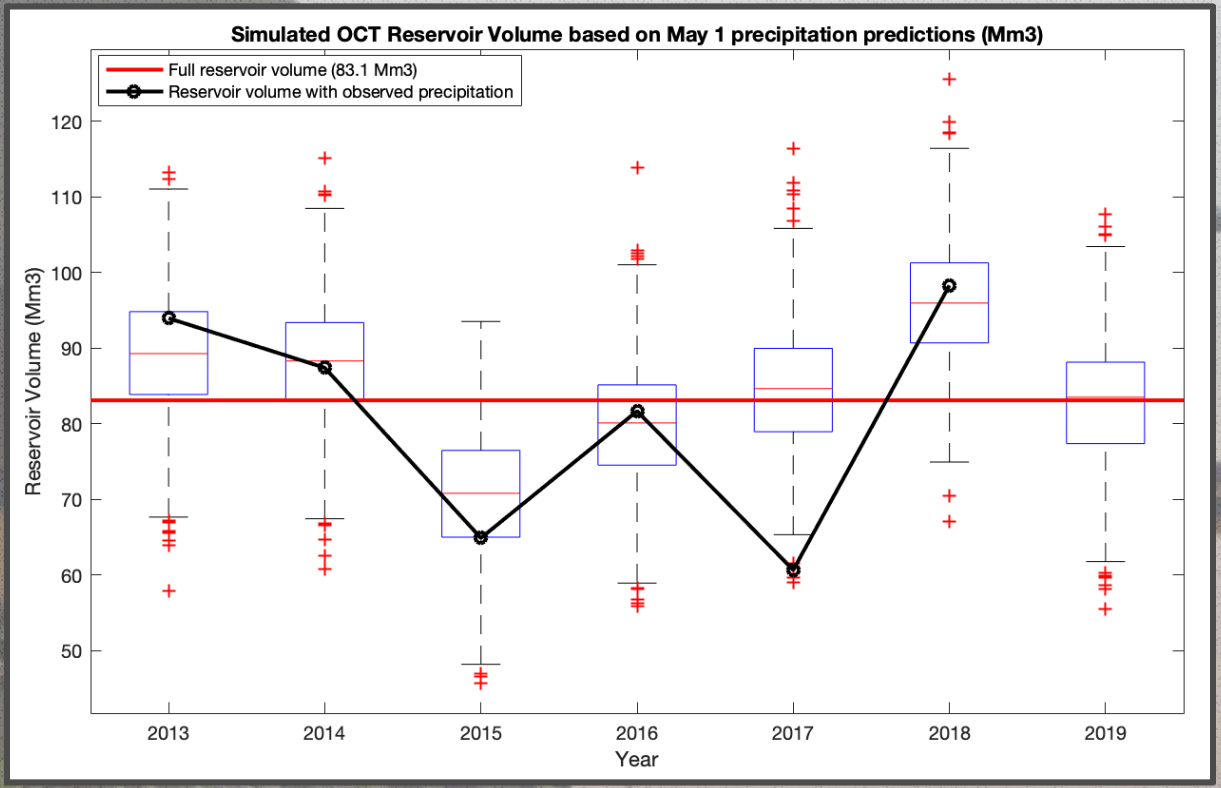
Reservoir fills

Does not fill



Valuable lead time for reservoir prediction?

When are reservoir volume predictions valuable to ABA, farmer cooperatives, others?



BULLETIN DEVELOPMENT

development of Kiremt and Bega PIRE forecast bulletins

Sarah Alexander

PIRE Annual Meeting

November 20, 2019

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Precipitation Predictions for Blue Nile Basin, Ethiopia

April 2018

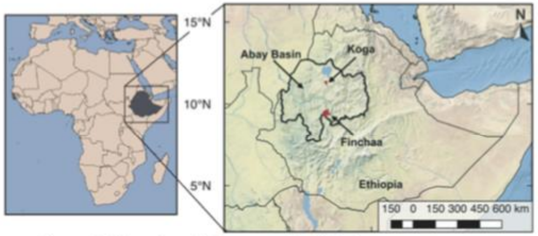


Figure 1. Map of prediction areas in Ethiopia.

Climate variables (temperature and pressure at the ocean surface, wind, others) influence the amount of rain received in Ethiopia. These patterns and historical data on rainfall provide information as to the possible amount of rain that will come during the next season

2018 June-September Season

The current prediction for the Blue Nile Basin area overall, as well as Koga and Finchaa local areas, indicates that average to slightly wetter than average precipitation conditions may be expected in the basin. Graphs below show the chance of rainfall by category for each region. Years of similar rainfall amounts and corresponding yields of key crops are also shown.

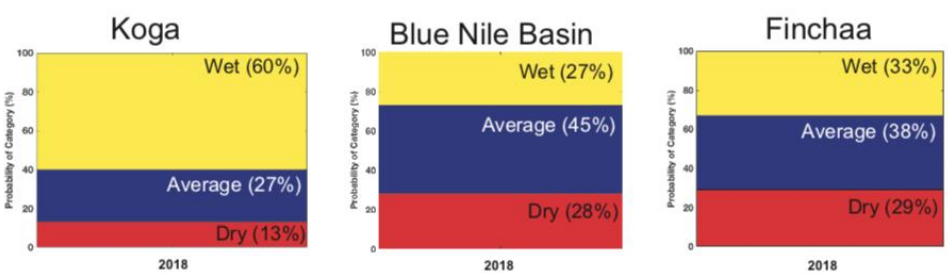
Expected rainfall values:

Blue Nile Basin - 977 mm
Koga - 1123 mm
Finchaa - 1027 mm

→

Similar past years: 1991,1996

ex. 1991 yields for key crops
Maize - xxx
Teff - xxx



What does this mean?

Based on observations of climate patterns this spring, we think the coming June-September (JJAS) rainfall will be about the same as would be expected in most years. This means that planning and management decisions may not need to be adjusted. In comparison with last year, we might plan for approximately 90% of the rainfall that was received in 2017:

Example:

Blue Nile Basin

2017:
Rainfall: 1079 mm
Maize: xxx
Teff: xxx

→

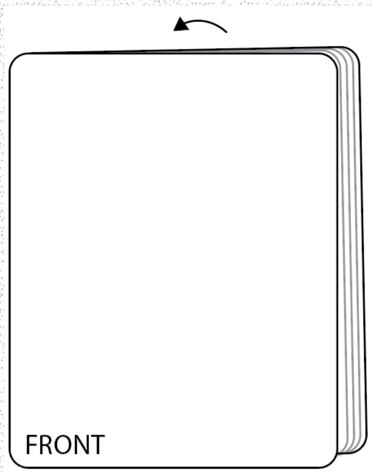
2018 (expected):
Rainfall: 977 mm
Maize: xxx
Teff: xxx

From first draft to communication…

What was the process and timeline of bulletin development for the PIRE project?

May 2018 – first bulletin draft discussed at PIRE annual meeting

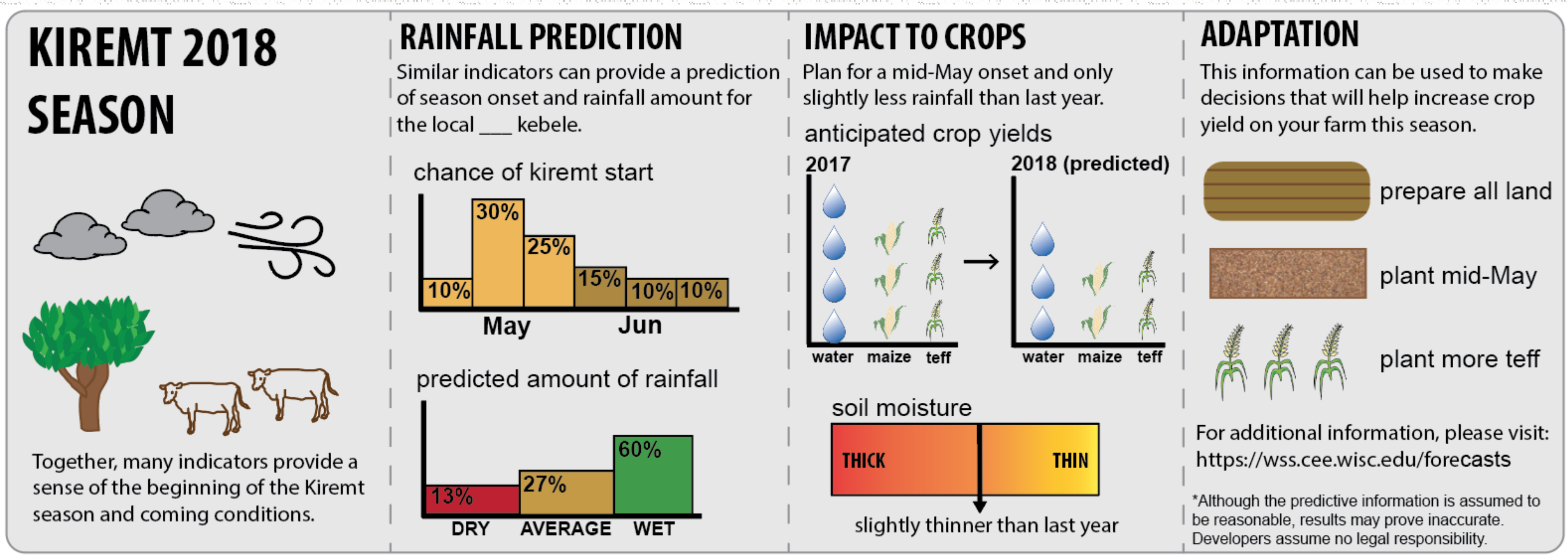
Review, revisions & more iterations



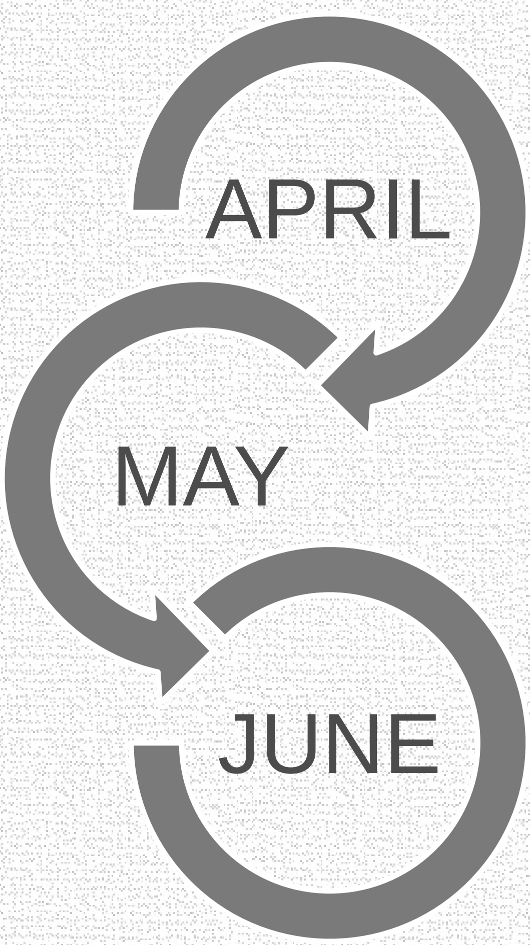
Dec 2018 – collaboration & meetings at IFPRI

Jan/Feb – conversations with Liz & team, iterations on prediction & bulletin timeline (hydrology meetings & brownbag)

Mar – review of bulletin draft (PIRE & Ethiopian colleagues), refine timeline and engage Semu & Marmaru



Compile, translate, & communicate



Apr 1 – Liz proposes timeline based on ethnographic work

Apr 17 – Review next bulletin draft, Ethiopia meeting for bulletin training with 2018 data

Late Apr – Ethnography team sends feedback, bulletin updates

April 29 – Bulletin development workshop

May 2-5 – Translation

May 6-9 – Trainings in Ethiopia

Late May – Follow-up by ethnographic team

June – Follow-up by the ethnographic team

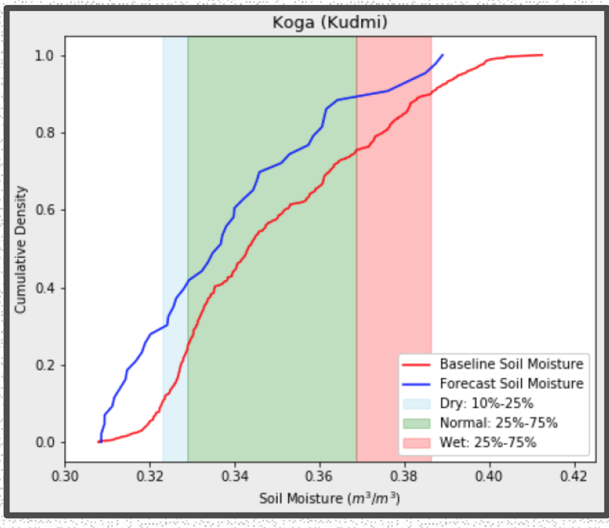
Using science communication best practice

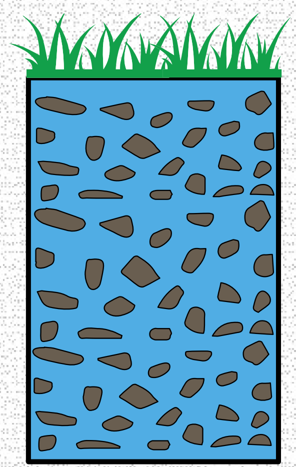
Elements needed for useful forecasts:

1. Information tailored to end-user needs
2. Partnership with existing institutions
3. Inclusive communication that builds capacity to understand probability

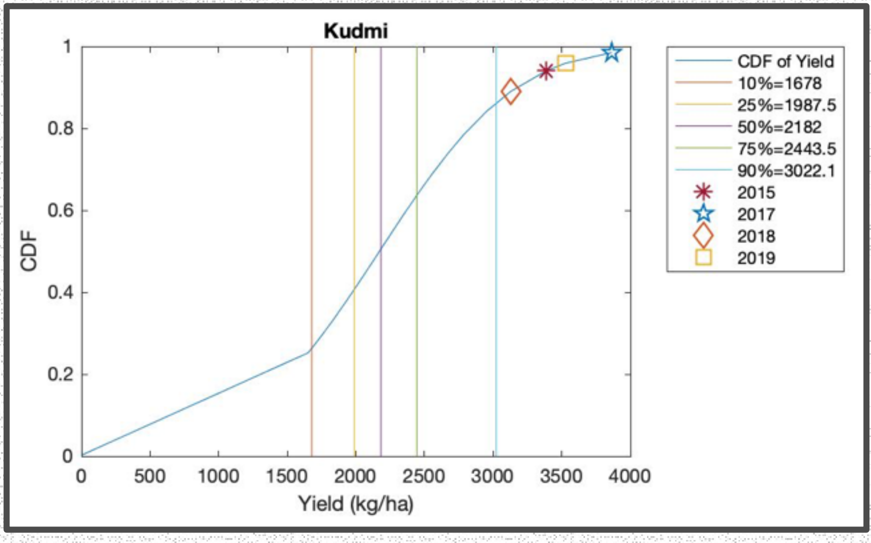
(Patt et al., 2007)

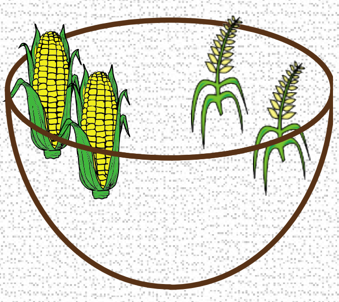
Modeling output to visual communication





Through stakeholder and group feedback, raw modeling output was made more easily understandable for the agricultural extension audience





2019 KIREMT SEASON RAINFALL PREDICTION - KUDMI

Due to conditions favorable for rain, Kiremt season 2019 is predicted to have normal or slightly above normal (wet) total rainfall. The onset is expected in end of May.

KIREMT SEASON PREDICTION

chance of kiremt start

Onset is expected in the end of May.

□□□□ 1–30, 2011

□	□	□	□	□	□	□
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

□□ 1–29, 2011

□	□	□	□	□	□	□
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

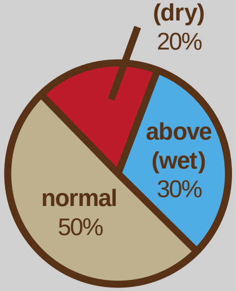
onset probability:

- **very low probability of kiremt onset**
- **low probability of kiremt onset**
- **moderate probability of kiremt onset**
- **high probability of kiremt onset**

total kiremt rainfall prediction

The most probable scenario is that Kiremt 2019 will have a similar total amount of rainfall as last Kiremt season.

- **Normal:** 50% chance total rainfall amount will be similar to last year.
- **Wet:** 30% chance total rainfall amount will be higher than last year.
- **Below:** 20% chance total rainfall amount will be lower than last year



PREDICTED IMPACT TO CROPS

anticipated crop yields

last year (2018) **this year (2019)**

last year (2018): **te** normal; **maize** normal

this year (2019): **te** normal; **maize** normal

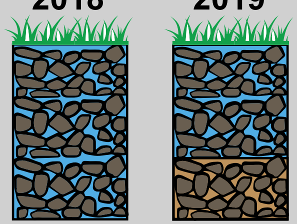
Te yields are expected to be slightly lower than last year. Maize yields are expected to be slightly higher than last year.

soil moisture

2018 **2019**

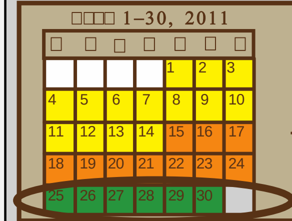
last year (2018): above normal

this year (2019): normal

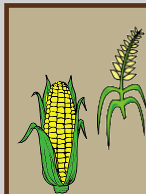


RECOMMENDATION

You can use this information to make decisions that will bene t crop management on your farm this season.



Kiremt onset is likely to be later this year, in end of May



Expect slightly lower teff yields and slightly higher maize yields, compared to last year.

For additional information, please ask your local agricultural extension.

*Although predictions & adaptations are assumed to be reasonable, individual farm outcomes may vary. Developers assume no legal responsibility.

This information is from the Water and Food Security PIRE project, with support from the U.S. National Science Foundation.

2011

2011

1–30, 2011

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

1–29, 2011

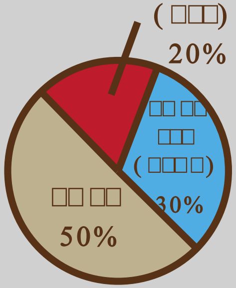
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

(2011)

50%

30%

20%



(2010) (2011)

2010

2011

2010

2011

(2011) (2010)

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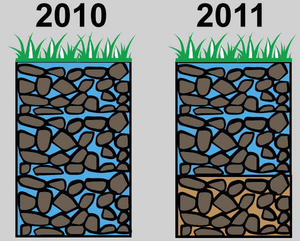
(2011)



2010

2011

2011

1–30, 2011

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
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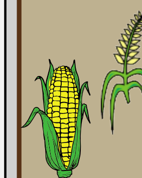


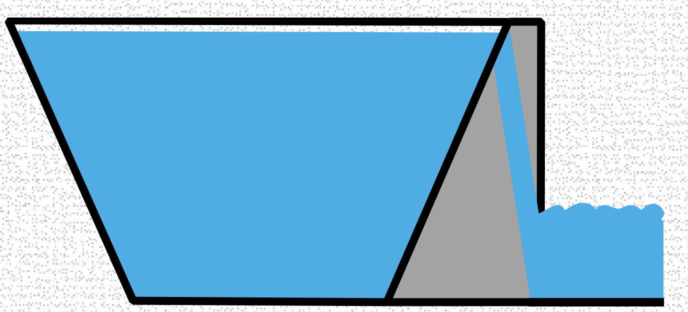
(2011)

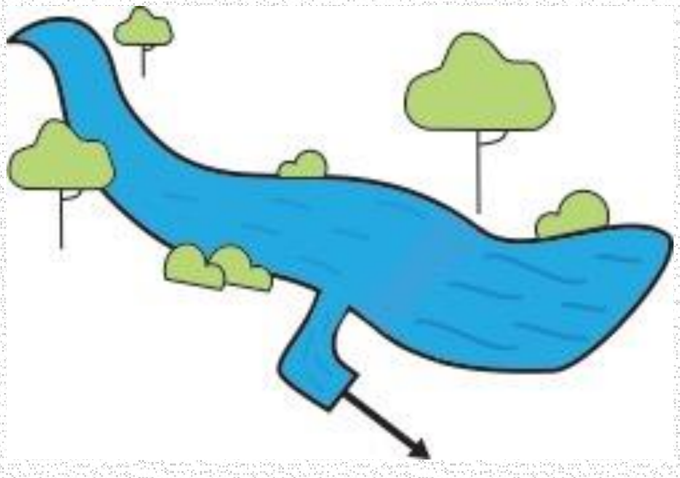
(2011)

*

(PIRE)

Bega season bulletin development





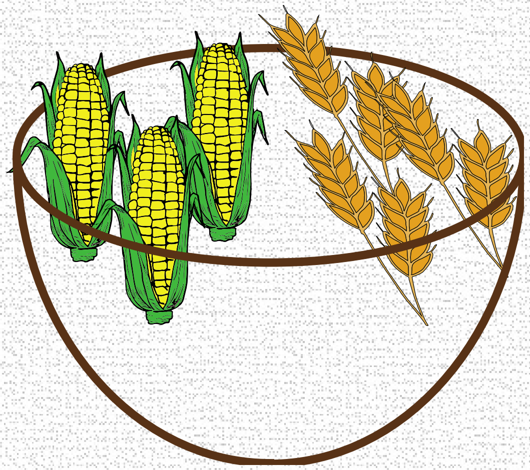
August – review draft of the dry season bulletin

Early Sept – data exchanges between hydrology team

Sept 9 – bulletin development workshop

Sept 9-17 – iteration to finalize prediction results

Bega season bulletin development



Sept 17-24 – translation and updates based on preliminary feedback from ethnographic team

Sept 26 - Oct. 2 – issue detected and updates to bulletin

Oct – meetings to distribute Bega bulletin and feedback from ethnographic team

Highlights of the communication approach

Direct user-produce engagement

Interaction between producers & users is imperative for effective communication
(Klopper et al., 2006; Lemos, 2015; Patt and Dessai, 2005)

Leverage existing, trusted networks

Trust is imperative, often of greater value than the information communicated
(Malka et al., 2009; Priest et al., 2003; Siegrist et al., 2012)

Understanding of probabilistic information

Comprehension of probabilistic information hinders uptake of seasonal climate forecasts
(Hartmann et al., 2002; Millner and Washington, 2011; Roncoli, 2006)

Continued development for 2020

- Bulletin issue dates
  - Trade-off between prediction capability and timing that is valuable for end-users

- Content on the bulletin
  - Feedback from end-users on the 2019 bulletin?
  - Requested information may or may not be predictable – what can we change and what isn't feasible?

- Changes to the development/implementation process
  - Engage agricultural extension for input on the 'adaptations' section of the bulletin?

NSF

PIRE: Taming Water in Ethiopia

Fahad Khan Khadim
Ph.D. Student, UConn

Groundwater Modelling in Multiple Scales in the Upper Blue Nile (UBN)

UNIVERSITY OF CONNECTICUT 1881

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

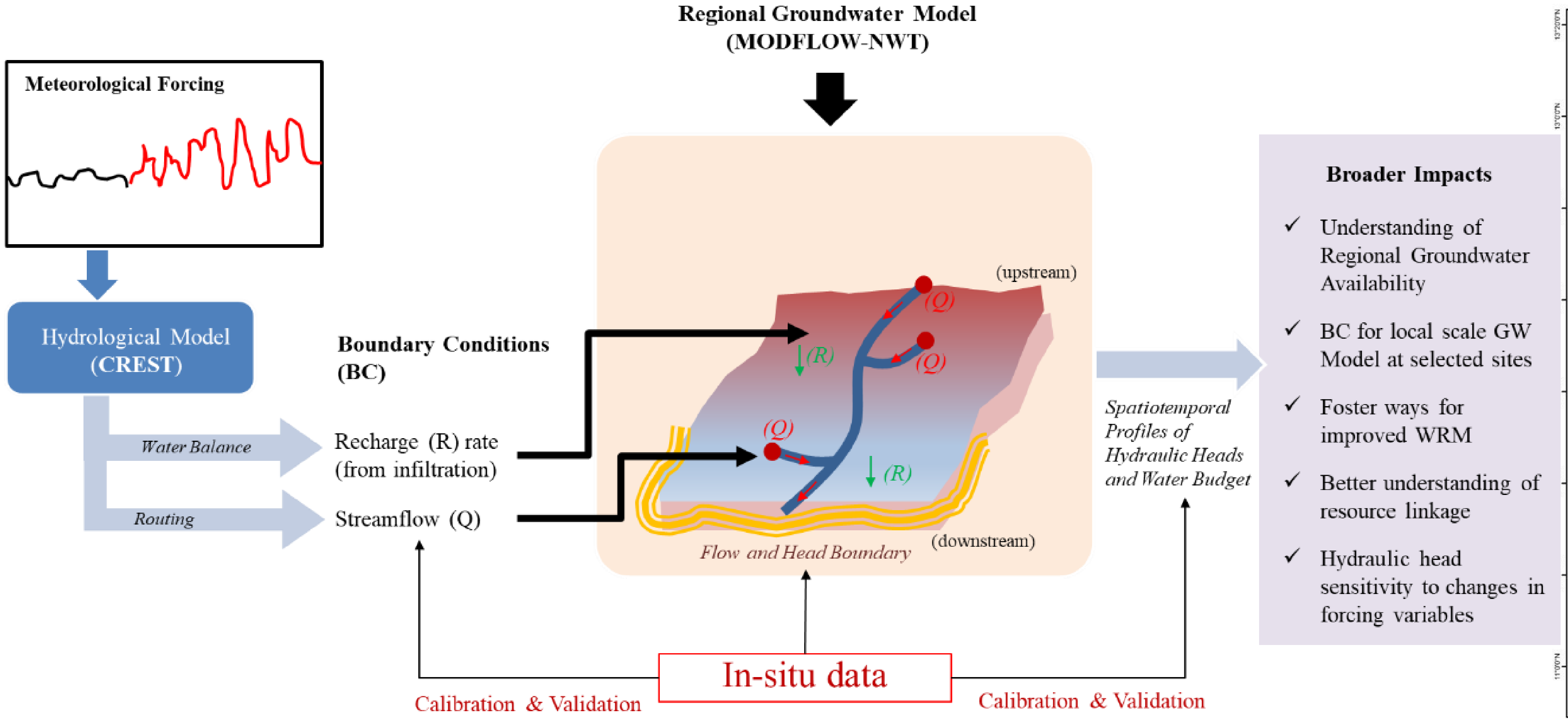
The UNIVERSITY of OKLAHOMA

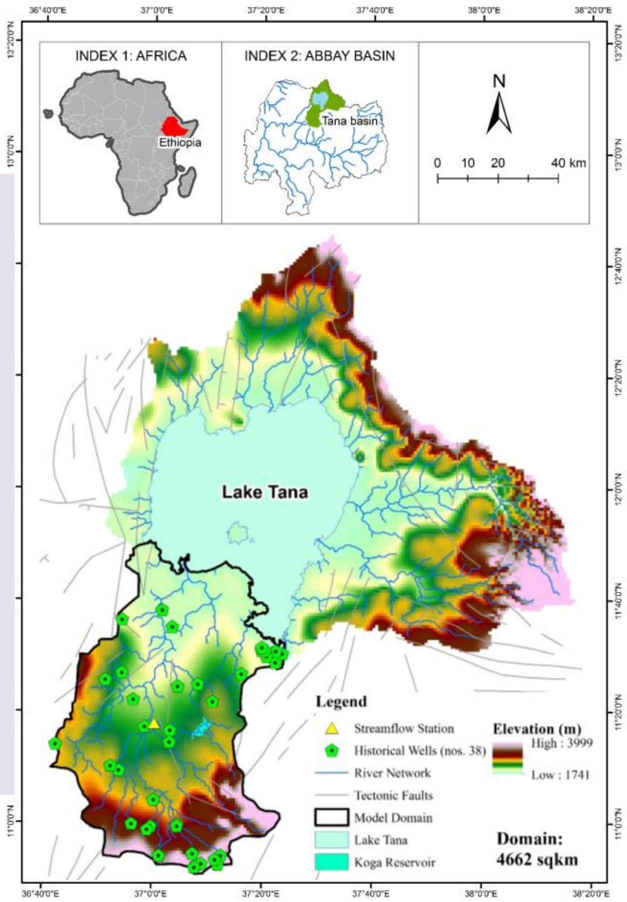
INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

Research Motivation

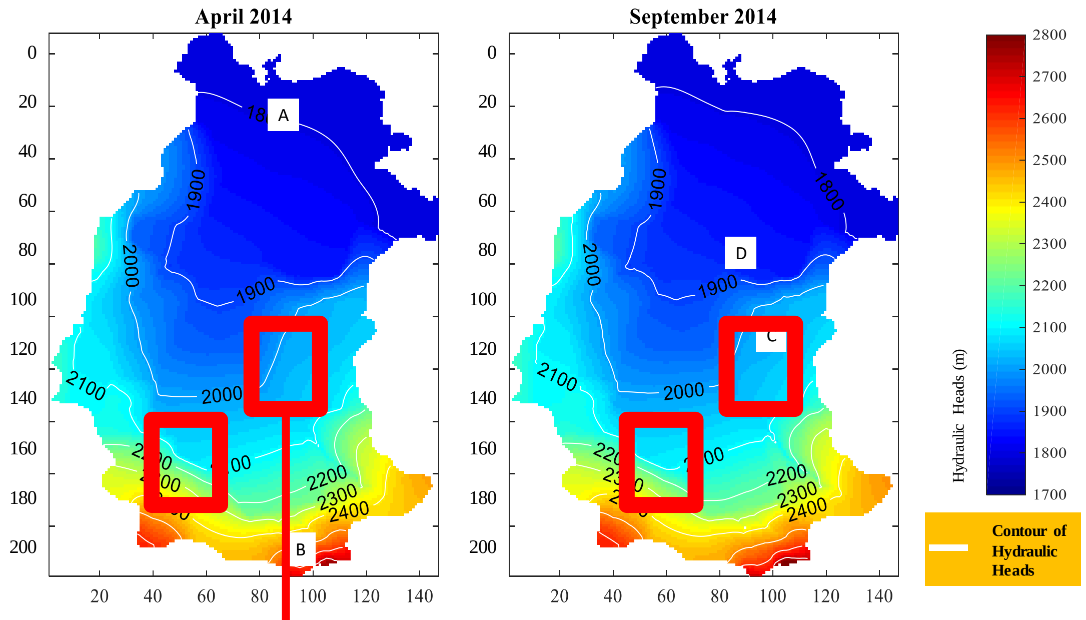
- Ethiopia has insignificant irrigation contribution from groundwater, exposing its 85% agriculture dependent population to water-food insecurity.
- Tremendous data scarcity have underscored the challenges and importance of developing groundwater models in the UBN
- GW resources in Ethiopia have the potential to buffer climatic variability-induced vulnerability
- Understanding the relationships of water management and food security

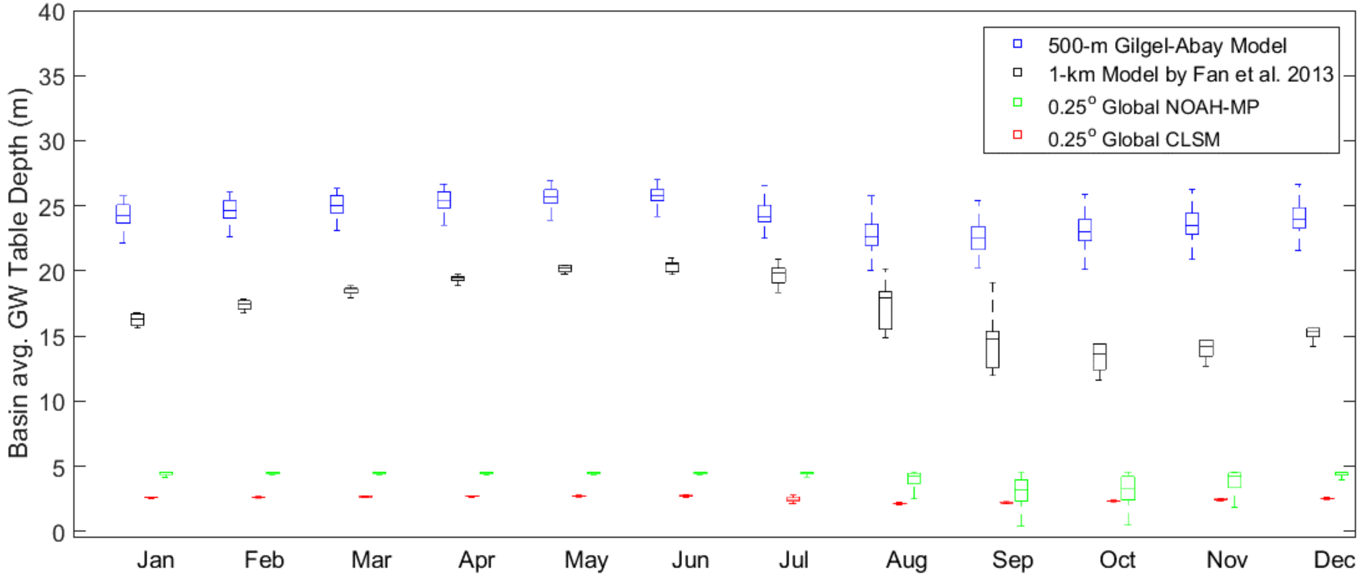
GW Model Scales: Regional and Local



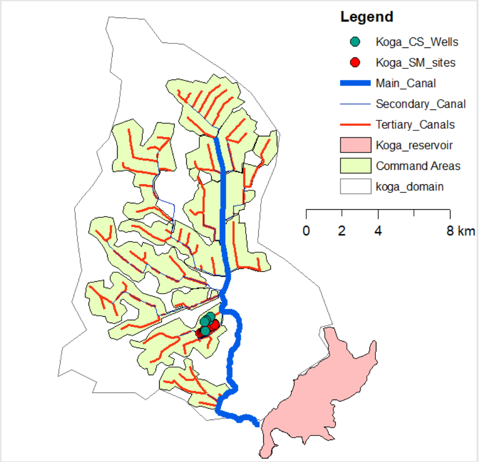


Regional Model (Gilgel-Abay) Results



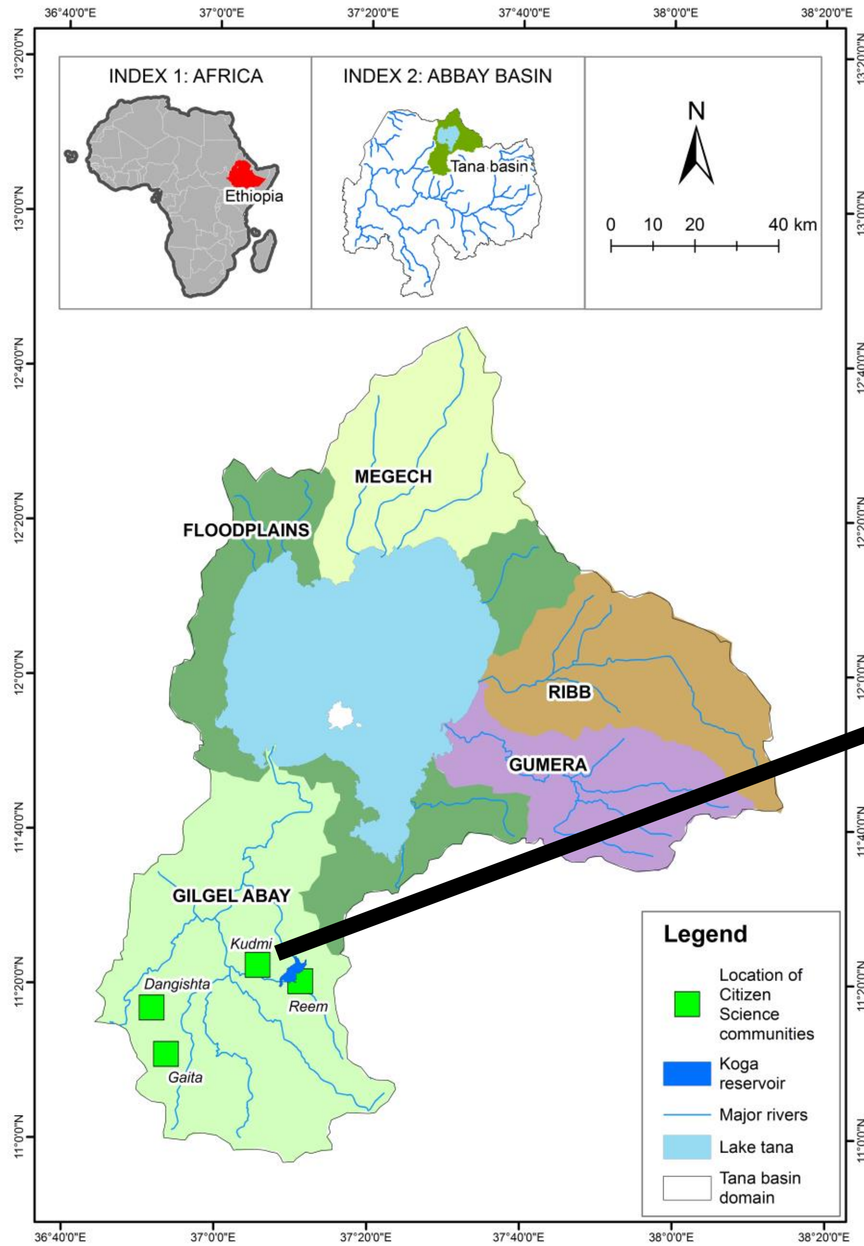


Head Boundary Condition

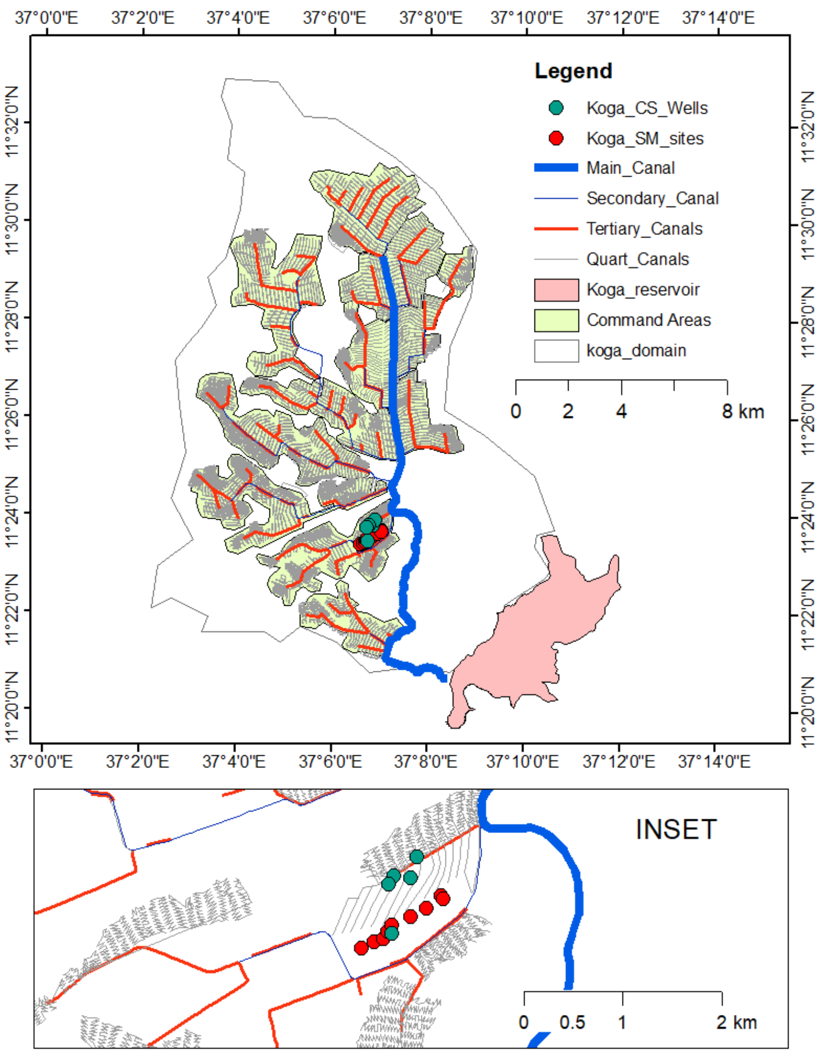


- A paper is submitted with the results of the regional Gilgel-Abay model
- Now I am working with local groundwater models, which also include the unsaturated zone

Model Introduction: **KOGA** and QUASHNI



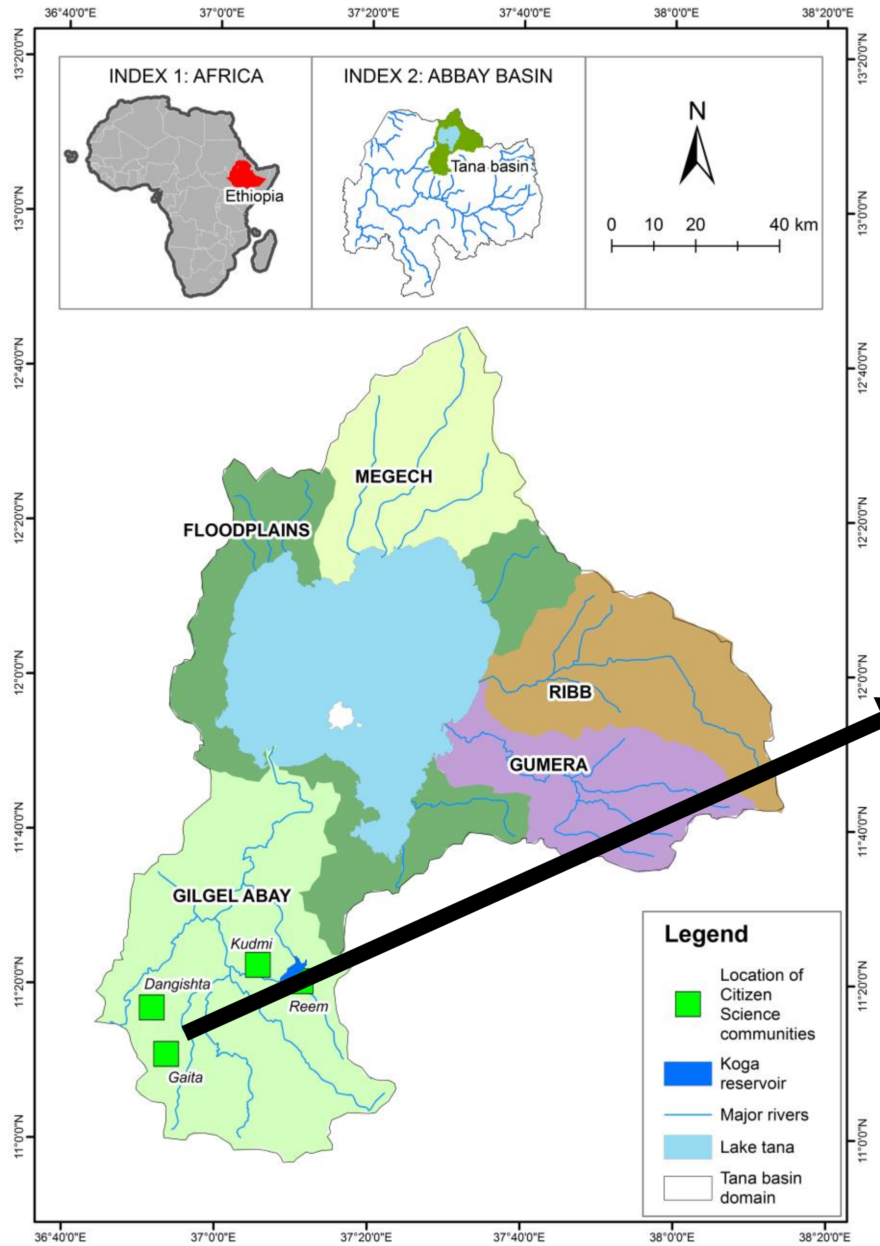
KOGA GW Model (in KUDMI)



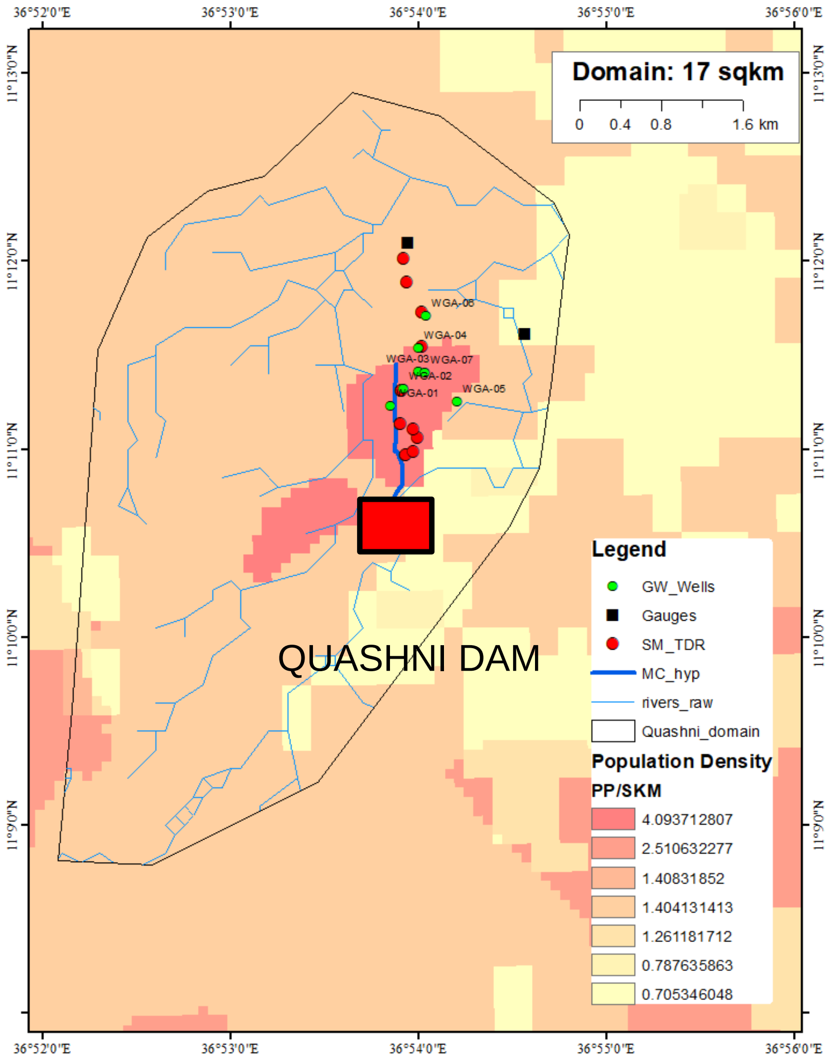
Data Availability in Koga:

1. Irrigation Release from ABA
2. Citizen Science data (soil moisture, and groundwater levels

Model Introduction: KOGA and **QUASHNI**



QUASHNI GW Model (in GAITA)

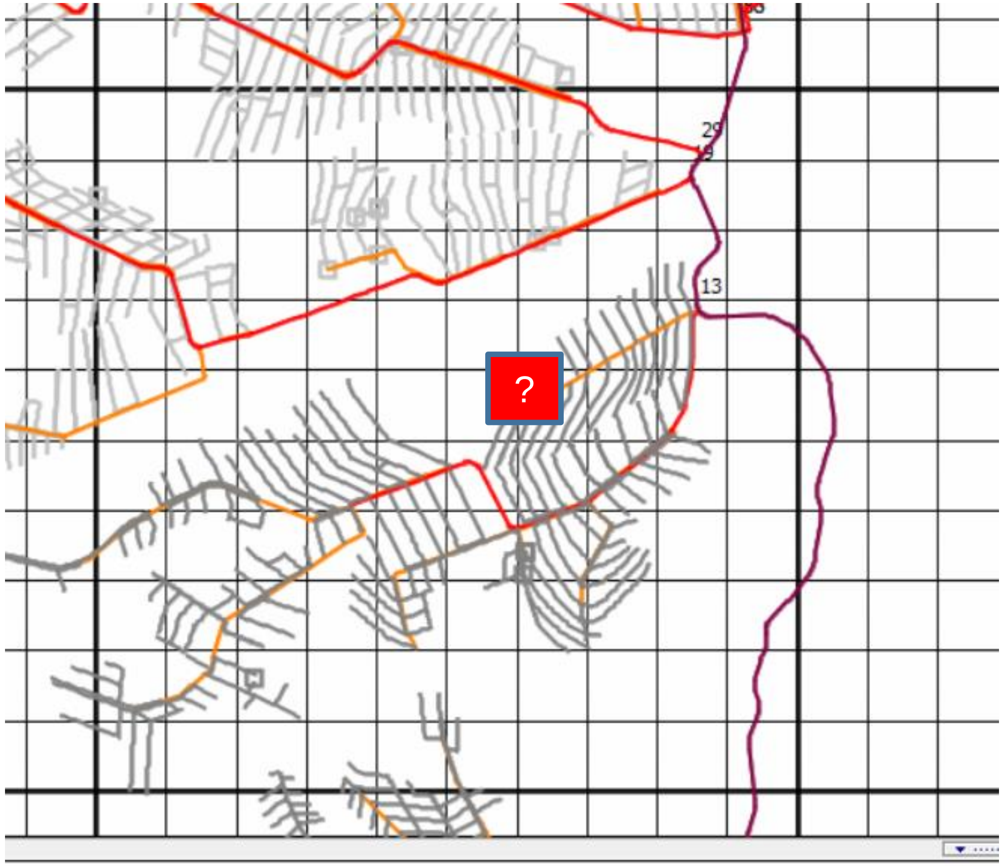


Data Availability in Quashni:

1. No Release data available, but from field visit the gate dimensions are obtained (**0.58m** x 1m)
2. The gate is opened from November – April for Irrigation
3. Citizen Science data (soil moisture, groundwater levels, river stage

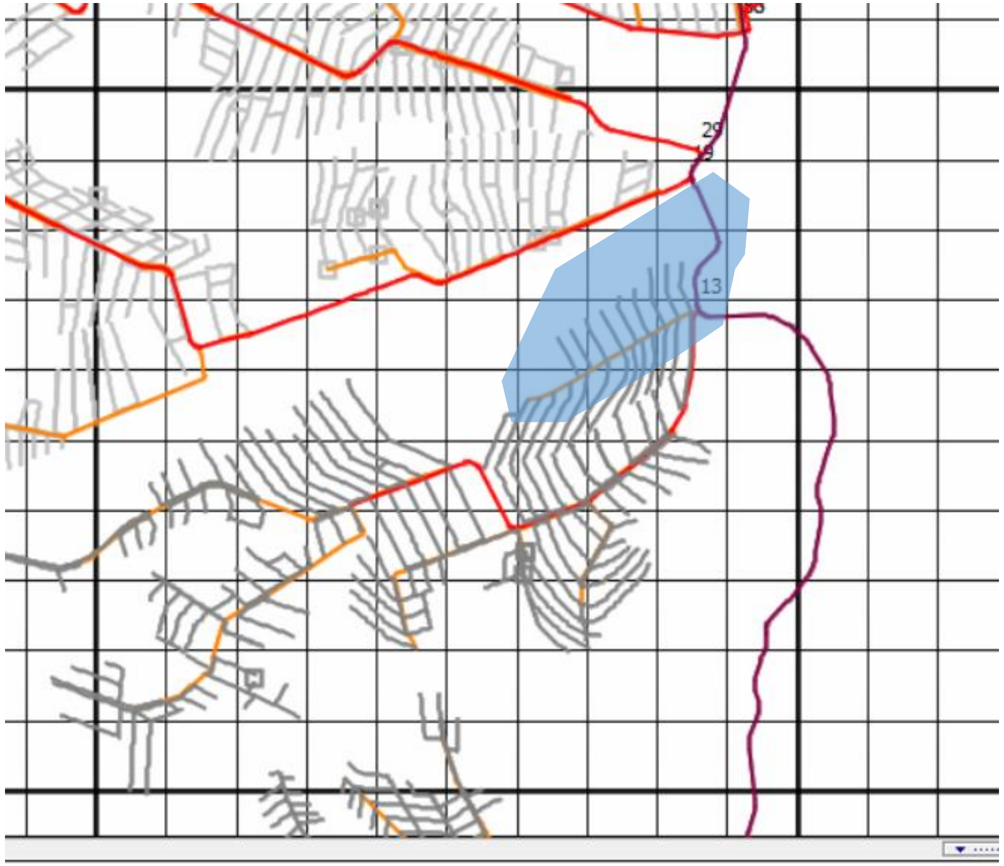
Concept of Adding Distributed Irrigation in Local Models

1. Calculate Flow at the End of each Tertiary Canal (earth canals) during irrigation



2. Add that flow as precipitation over a polygon, encompassing pixels represented by the supporting field canals

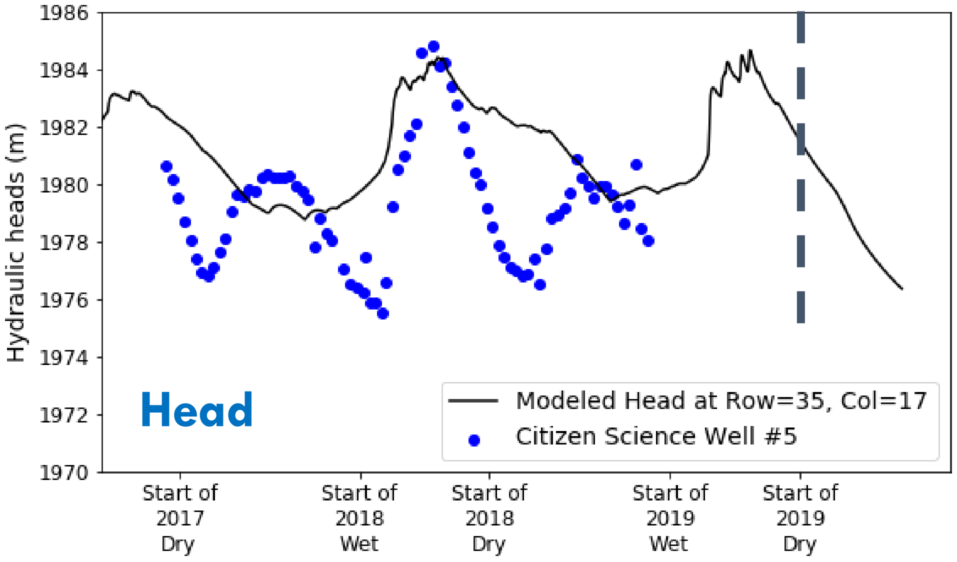
   - Irrigation is provided as 12-hr breaks (daytime)

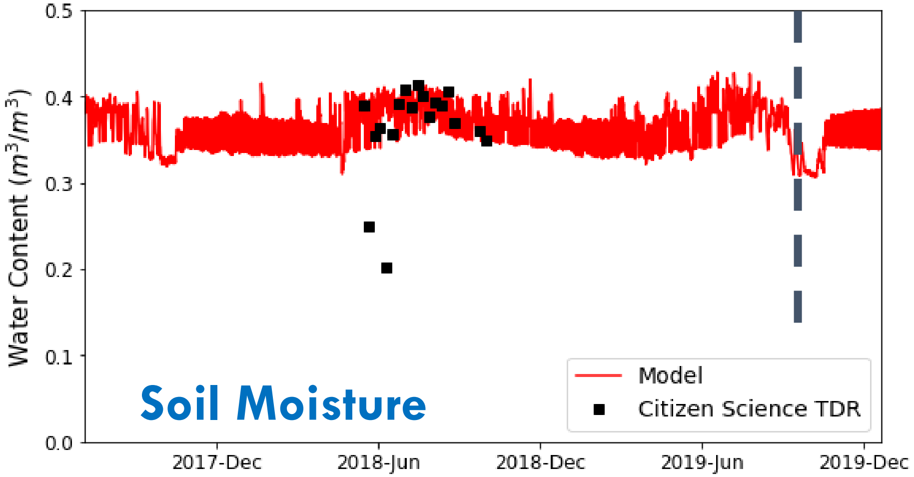


Model Results: Comparison against Citizen Science

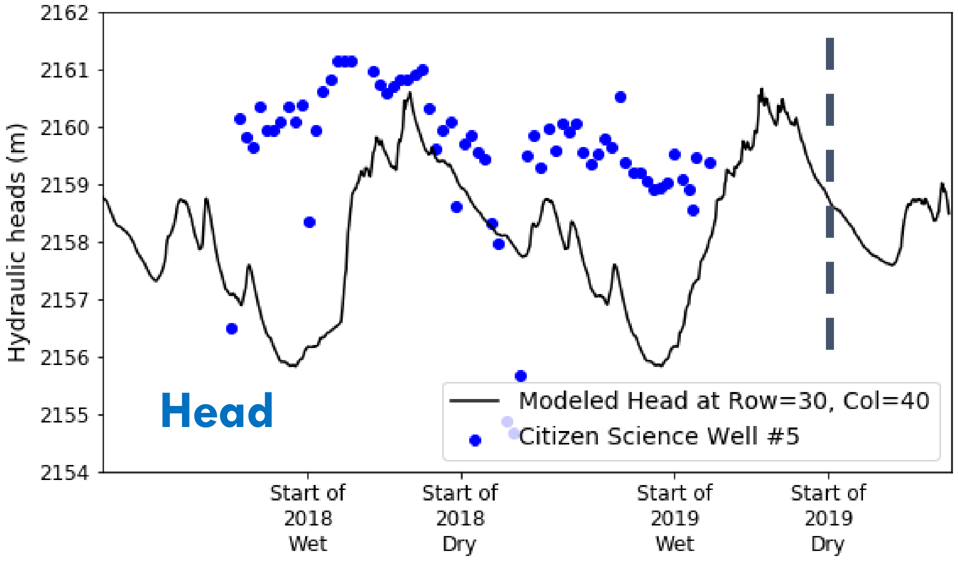
Head and Soil Moisture

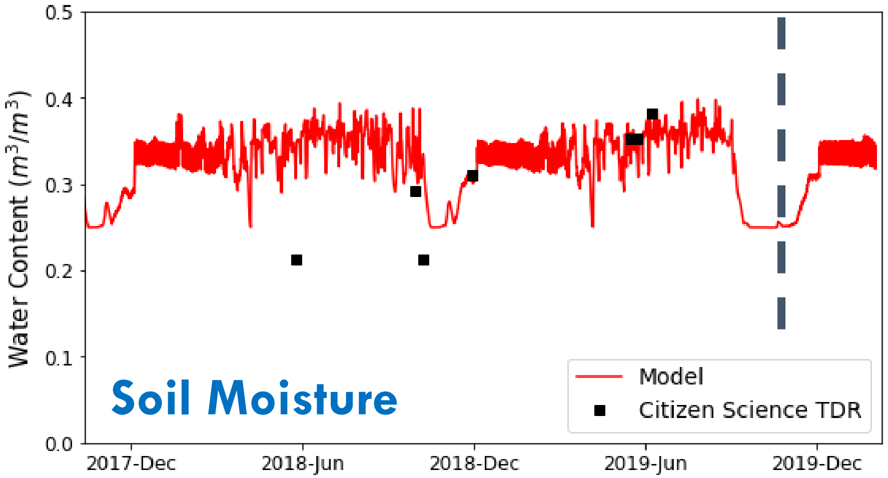
KOGA





QUASHNI

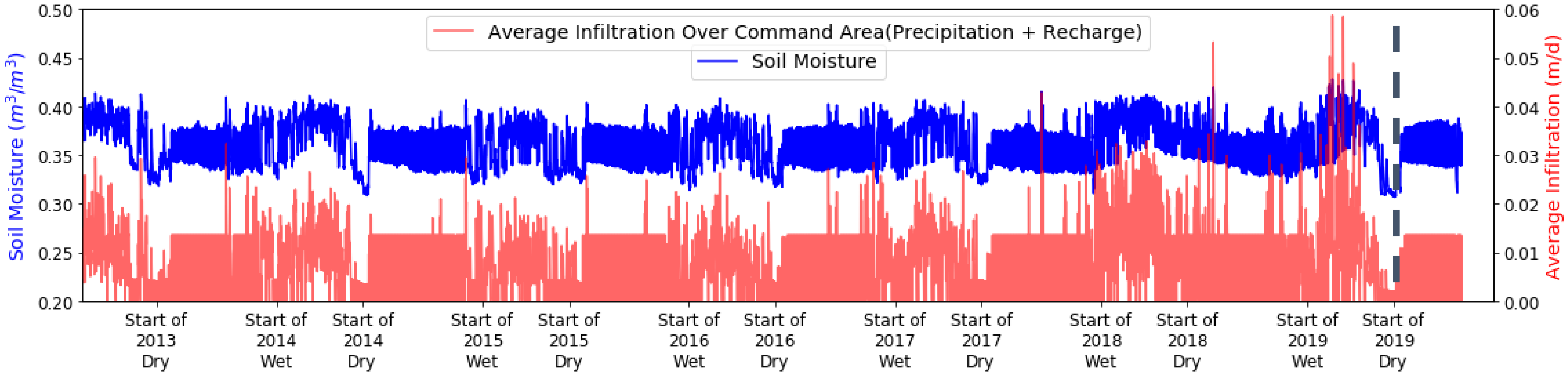




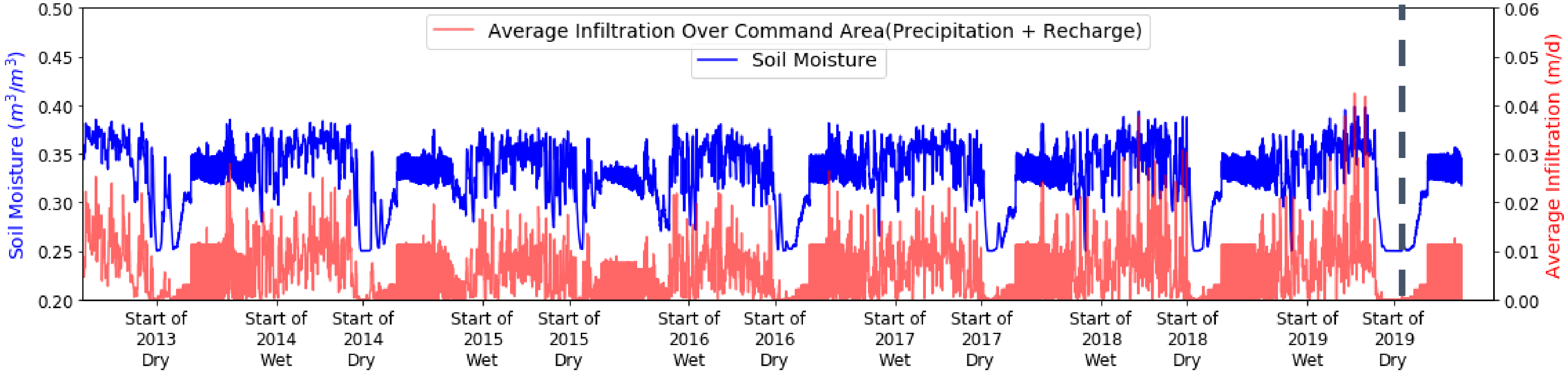
Soil Moisture Results for the Dry Season Forecast

Based on Sarah's forecast on start-of-dry-season reservoir conditions (83.5 MCM, and ~ 2015.5 m WL), **2016 was selected as an analogue year** and same release pattern was applied for 2019 dry season.

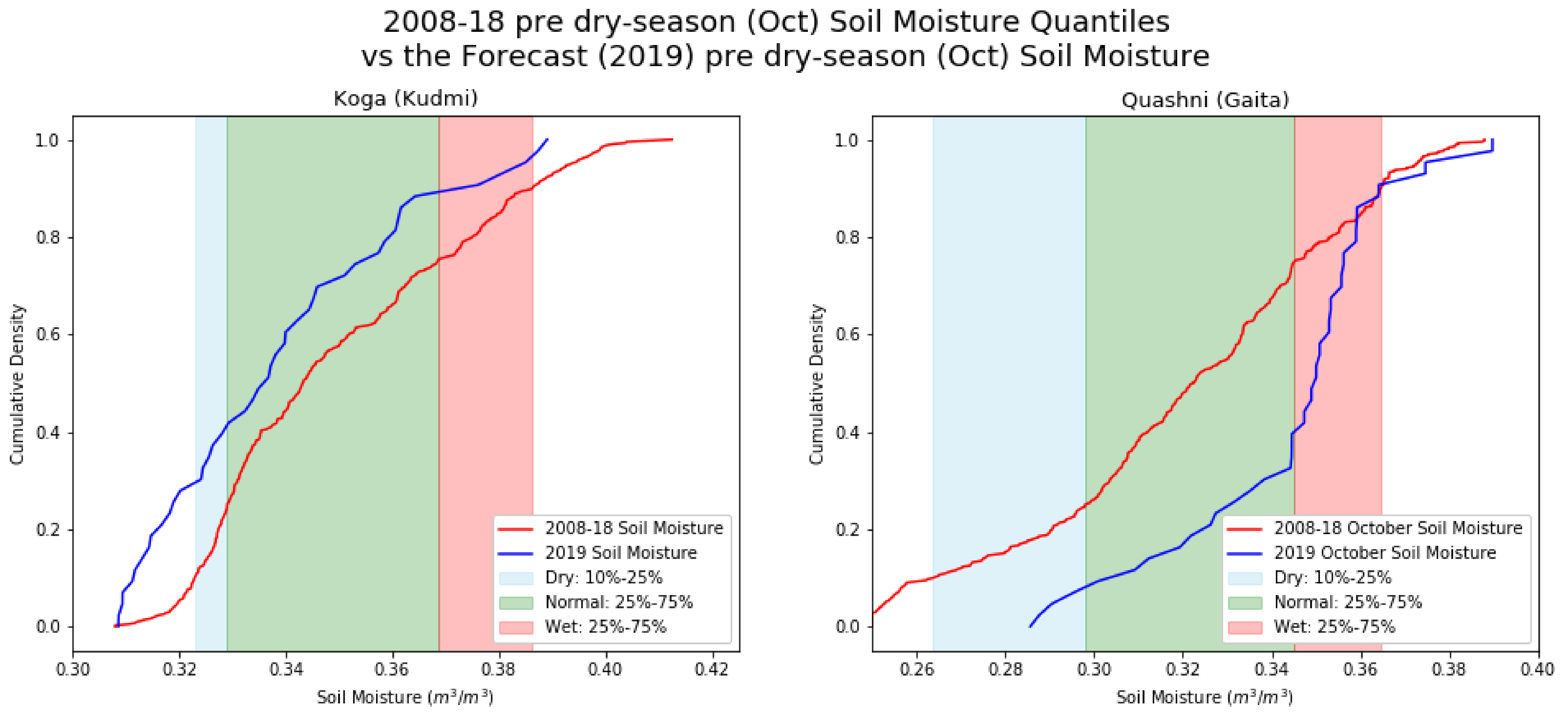
KOGA (CA 2)



QUASHNI



Pre-Season Soil Moisture Classification



Current Research (ongoing)

- Develop and evaluate the groundwater model in the local irrigated site of Koga (calibrate with hydraulic heads, soil moisture and evapotranspiration)

- Explore the vadose zone interactions and sensitivity of soil moisture with respect to irrigation

- Consider different irrigation and water management scenarios and highlight optimized strategies to improve water-food security in critical years


THANK YOU
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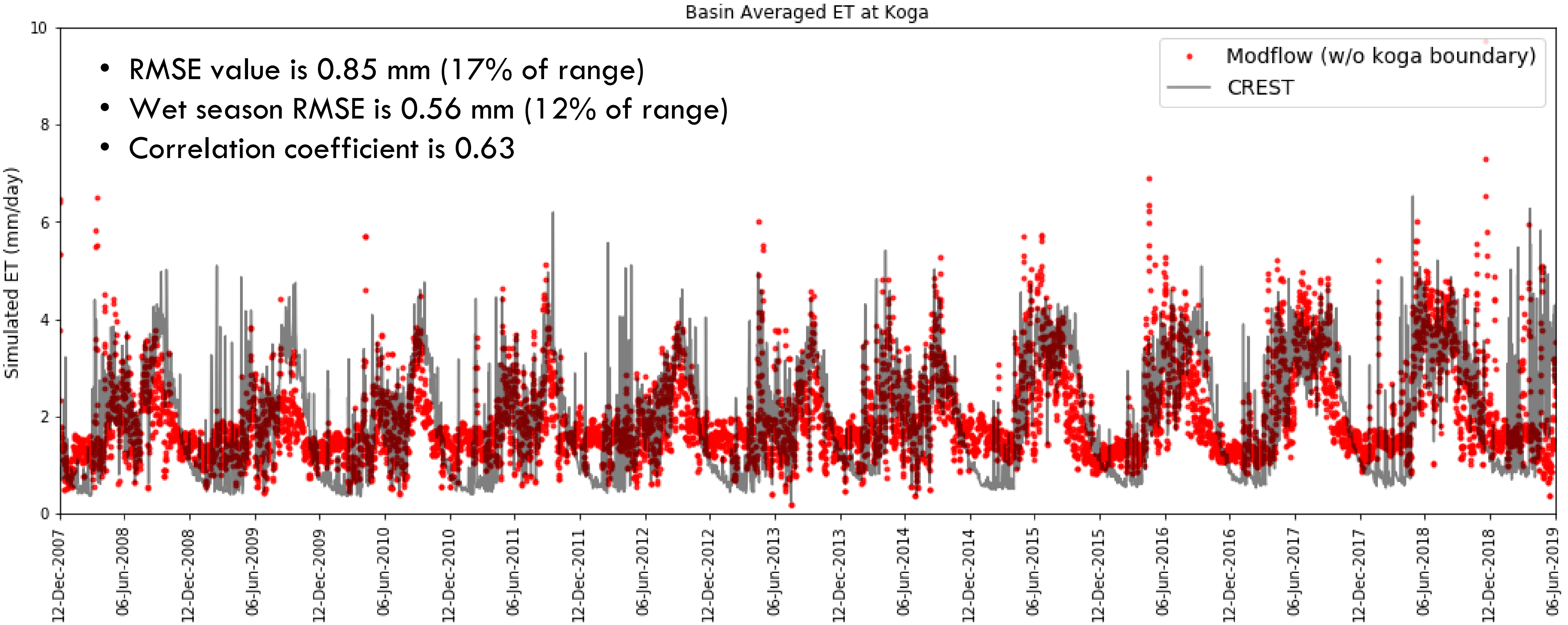
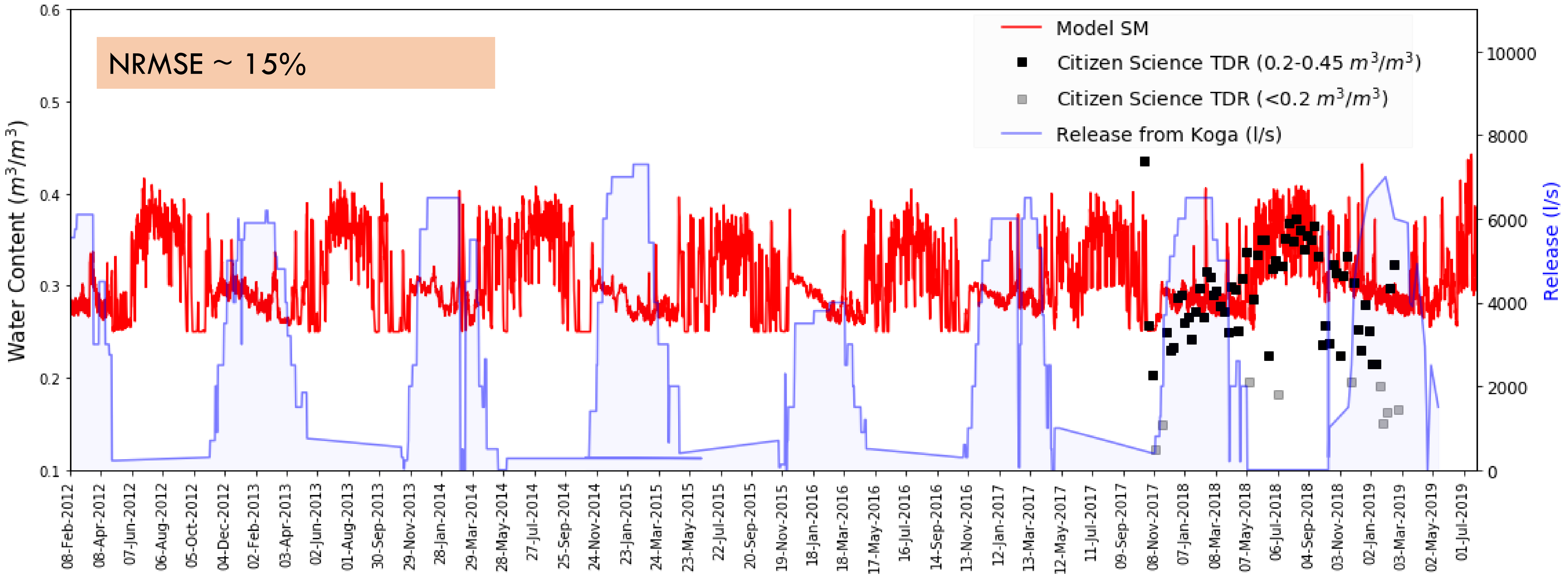
ET comparison with CREST (without irrigation)

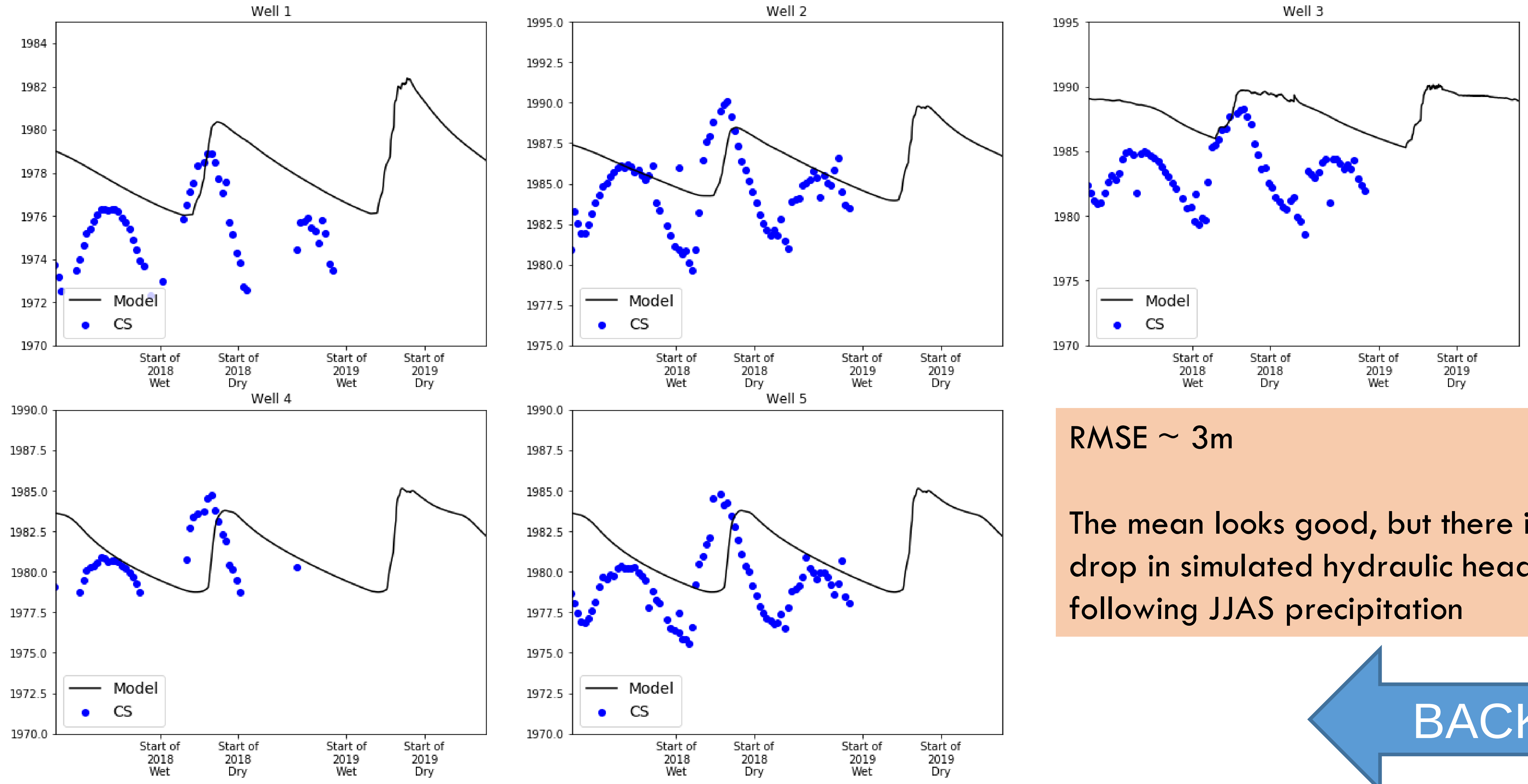
- RMSE value is 0.85 mm (17% of range)
- Wet season RMSE is 0.56 mm (12% of range)
- Correlation coefficient is 0.63



Soil Moisture Comparison with Citizen Science



Hydraulic Head comparison with Citizen Science

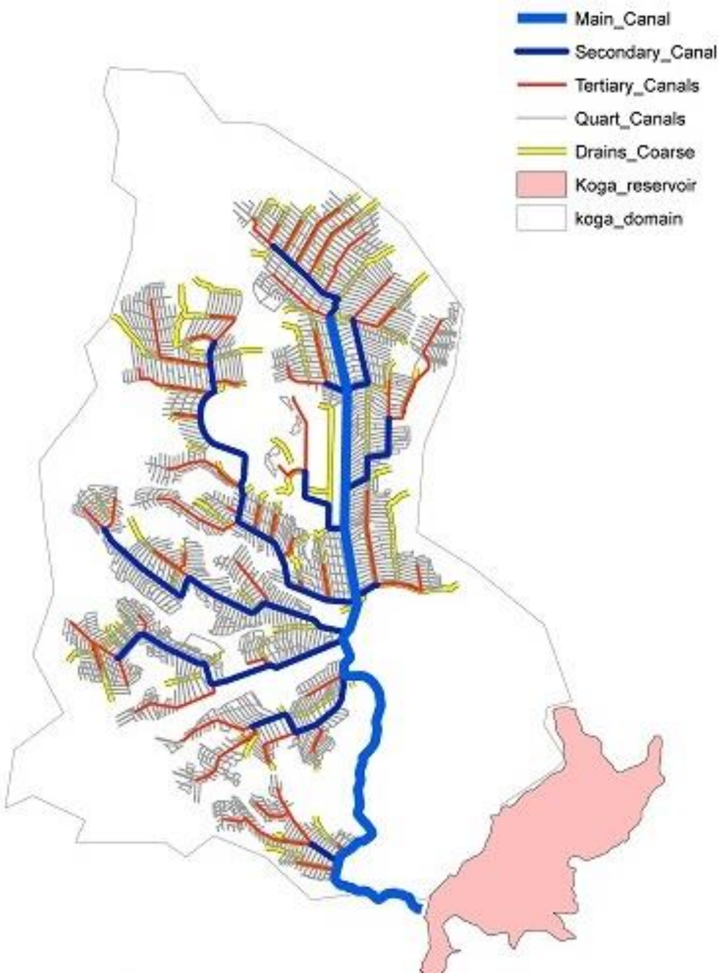


RMSE ~ 3m

The mean looks good, but there is no drop in simulated hydraulic heads following JJAS precipitation

BACK

Potential to Explore different Irrigation and Water Management (IWM) scenarios for Water-Food Security



KOGA IRRIGATION PROJECT

For a recent research, we are investigating these scenarios to see if it would be possible to attain better irrigation water availability and produce more crop yield for the historical drought years

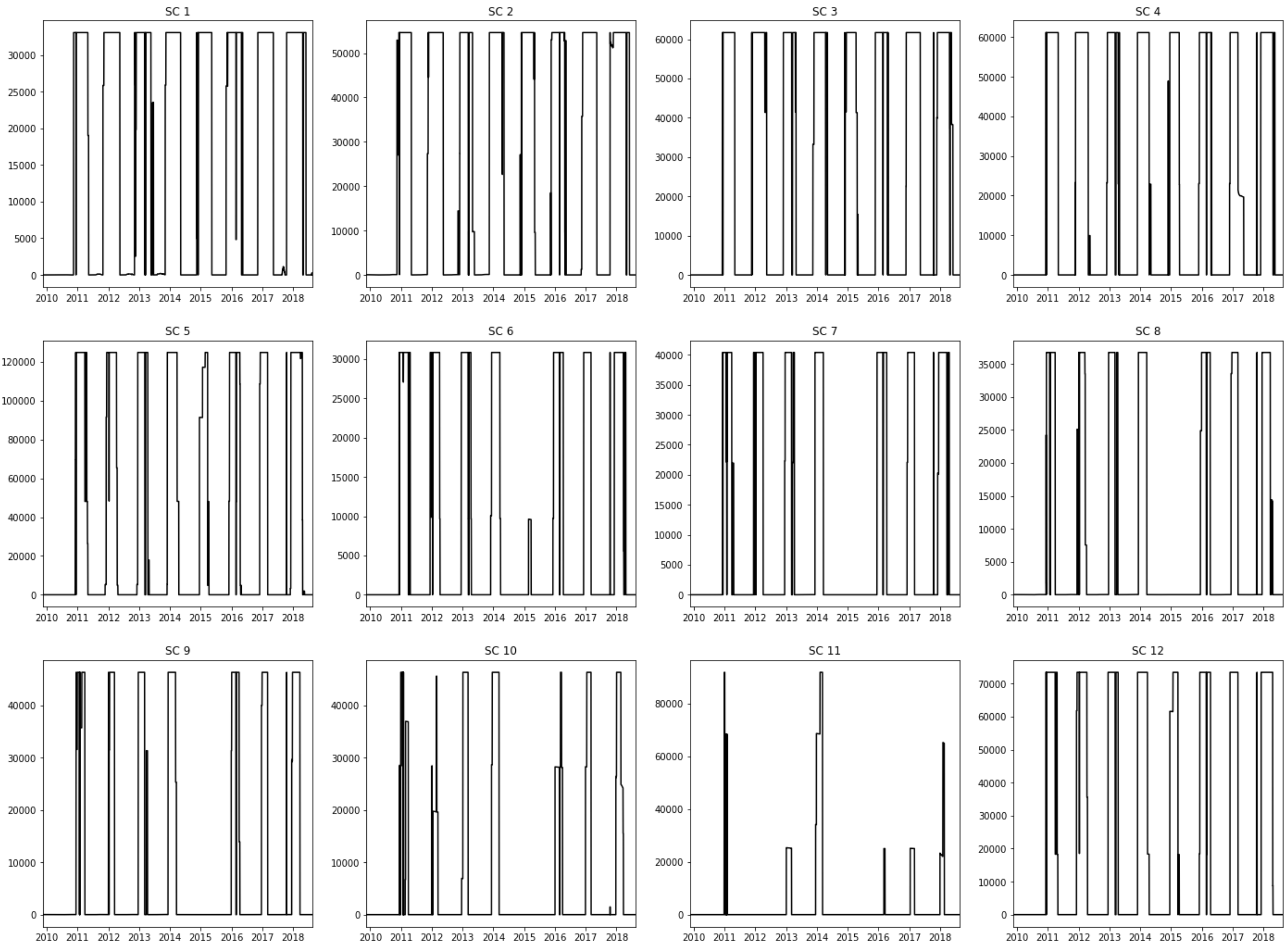
Scenario A: Business As Usual

Scenario B: Adjusted Gate Operations

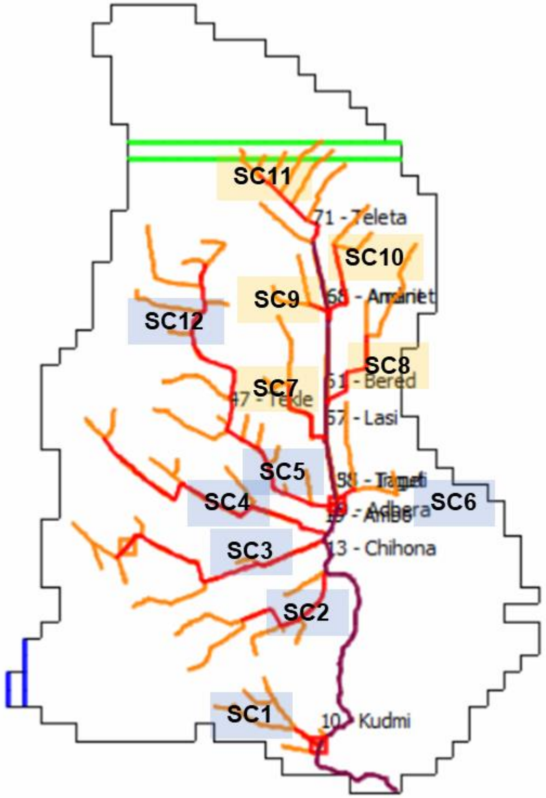
Scenario C: Use Groundwater for Supplement Irrigation

BACK

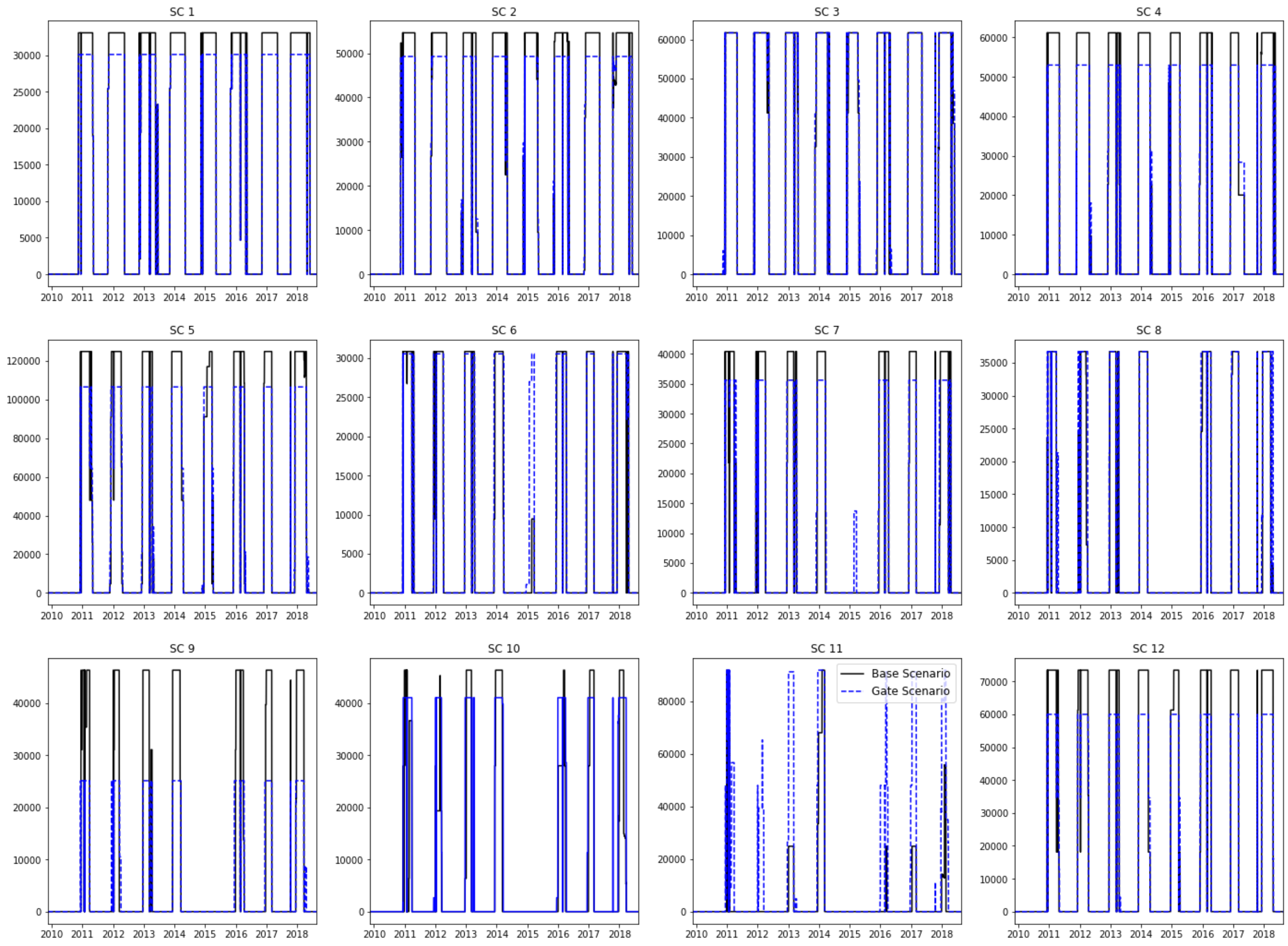
Secondary Canal Flows – Base Scenario

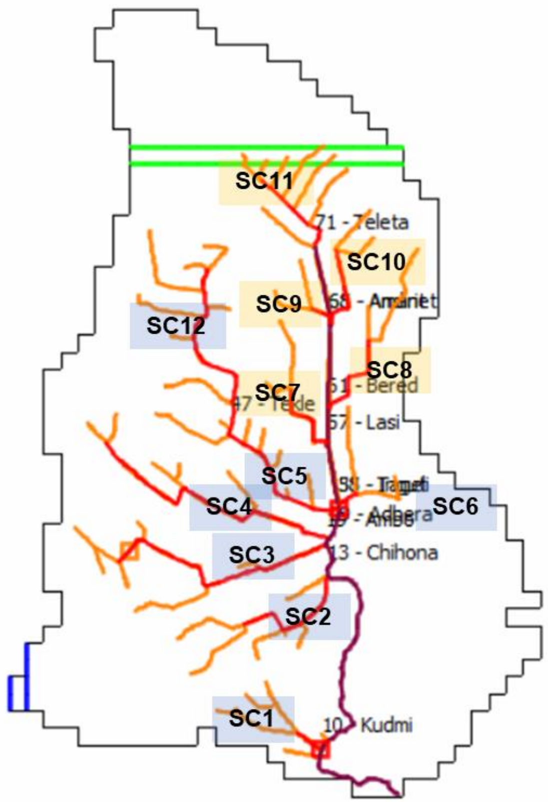


- Secondary Canal capacities are multiplied by 5/7 (to account for a 5 days/wk operation)
- Tertiary Canals are factorized by 4/7 (to account for a 4 days/wk)



Secondary Canal Flow – Gate Scenario



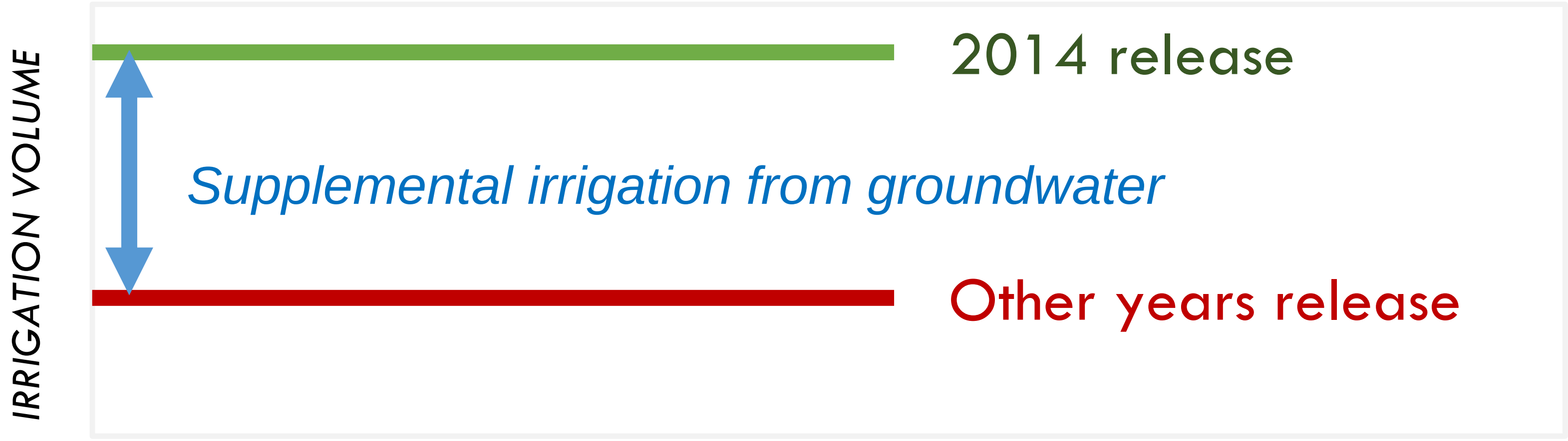


Assumptions for the Groundwater Scenario

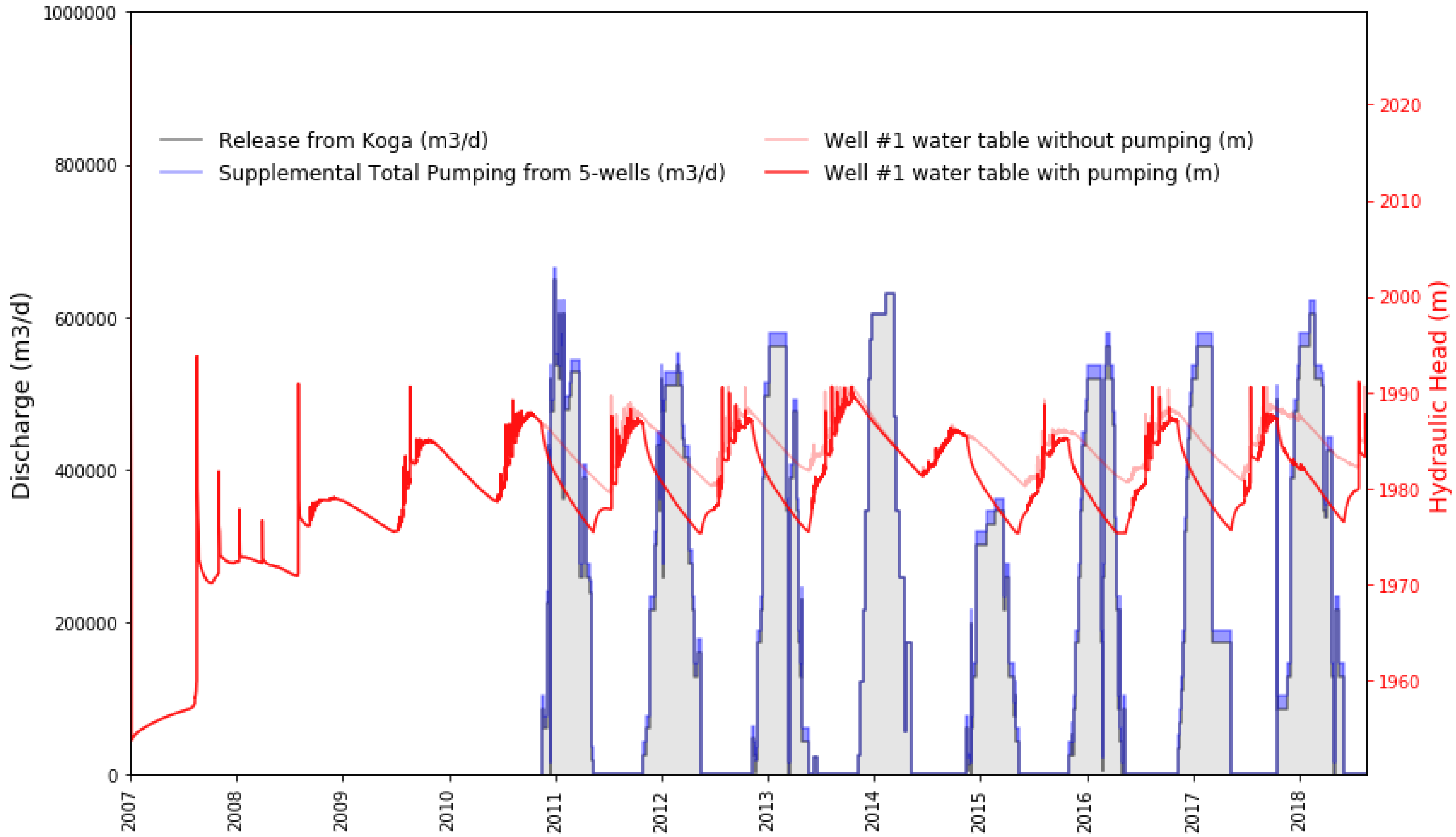
Artificially placed one GW well in the model

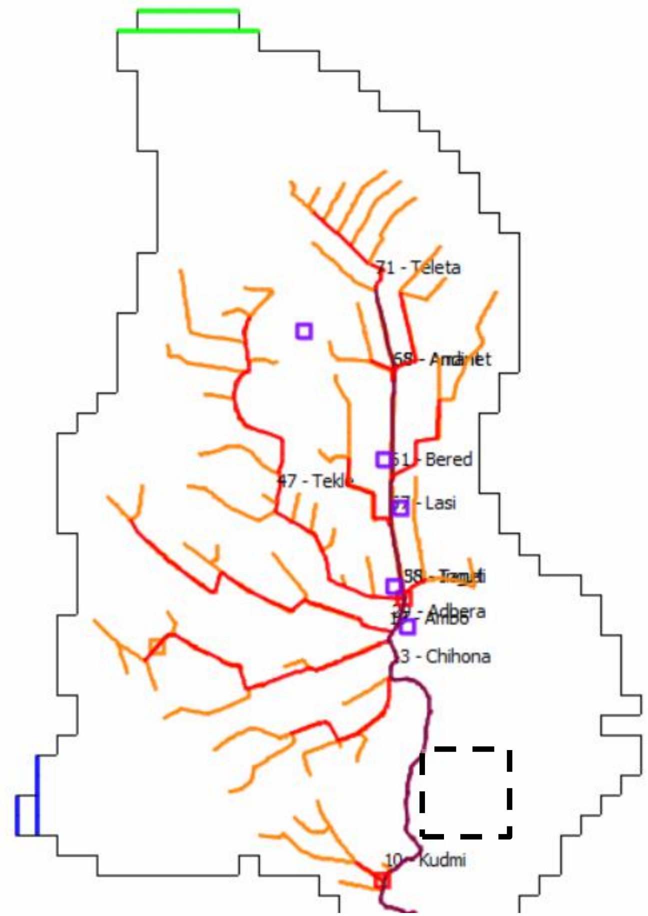
Over the historical years of releases, year 2014 was the highest release year

I considered that release as the best case, and for each other years release from 2011 – 2019, I pumped groundwater equal to the volume of the deficit amount (supplemental irrigation)

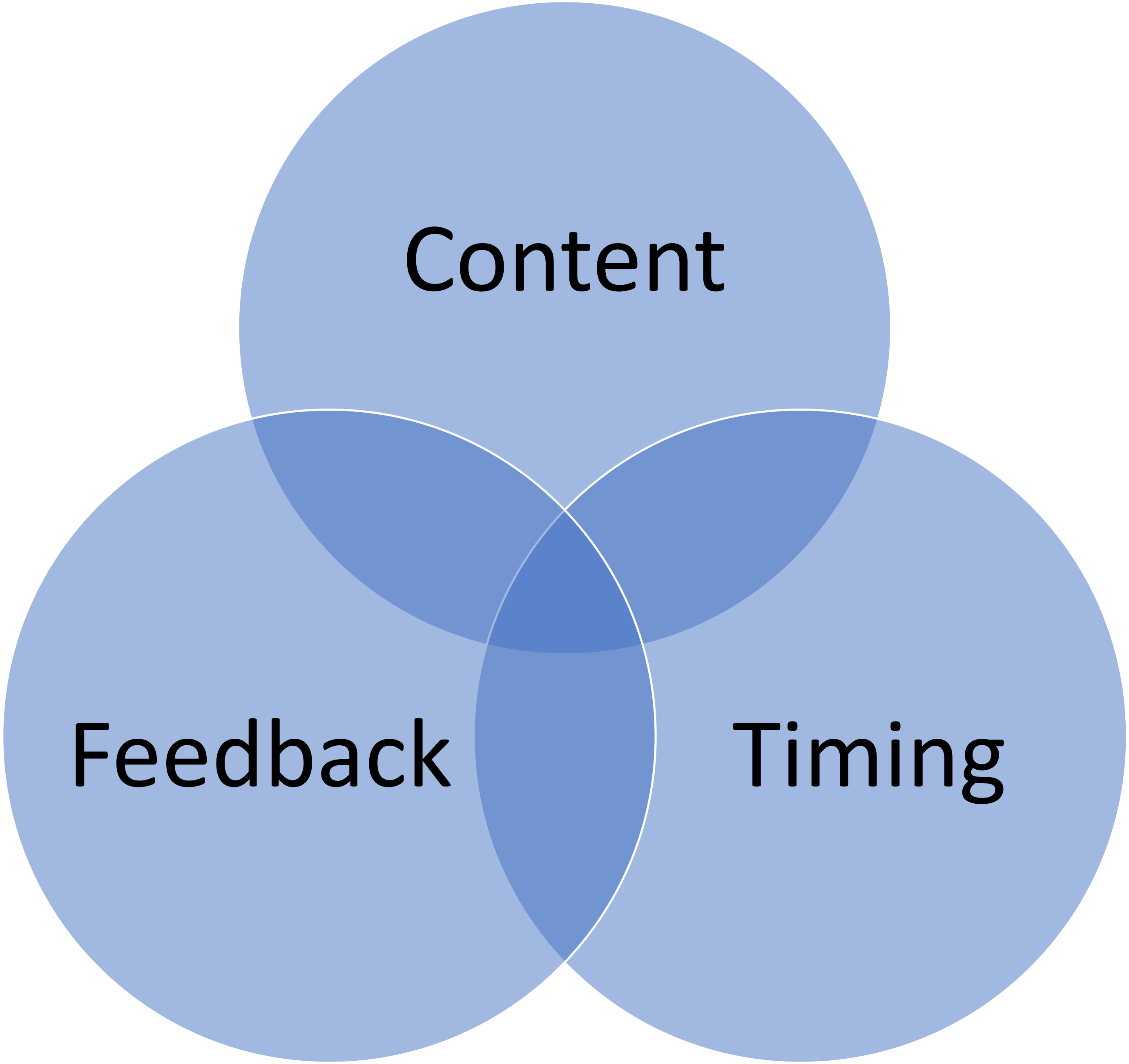


Groundwater Pumping Case: Preliminary Results





BACK


Content
Feedback
Timing

Questions for discussion

Reflections

- What worked well with bulletin development and communication?
- What elements could be improved for future years?

Improvement for 2020

- Summary of feedback received during communication?
- Specific content suggestions? Are these feasible to predict?
- What should the issue dates & timing be for 2020?

Any other thoughts?

Kiremt bulletin timeline

- **May 2018** – first bulletin draft discussed at PIRE annual meeting
- **Dec 2018** – collaborating with IFPRI
- **Jan/Feb** – conversations with Liz & team, iteration between hydrology/modelling on timeline for predictions and bulletin (hydrology meetings & brownbag)
- **Mar** – review of bulletin draft (PIRE & Ethiopian colleagues), refine timeline and loop in Semu/Marmaru
- **Apr 1** – Liz proposes timeline based on ethnographic work
- **Apr 17** – review next bulletin draft, Ethiopia meeting for bulletin training with 2018 data
- **Late Apr** – ethnography team sends feedback, bulletin updates
- **April 29** – Bulletin development workshop
- **May 2-5** – Translation
- **May 6-9** – trainings in Ethiopia
- **Late May** – follow-up by ethnographic team

Bega bulletin timeline

- **August** – review draft of the dry season bulletin
- **Early Sept** – data exchanges between hydrology team
- **Sept 9** – bulletin development workshop
- **Sept 9-17** – iteration to finalize prediction results
- **Sept 17-24** – translation and updates based on preliminary feedback from ethnographic team
- **Sept 26 – Oct. 2** – issue detected and updates to bulletin
- **Oct** – meetings to distribute Bega bulletin and feedback from ethnographic team

Modeling Crop Yields in Wet and Dry Seasons

Nov. 21, 2019

PIRE Annual Meeting

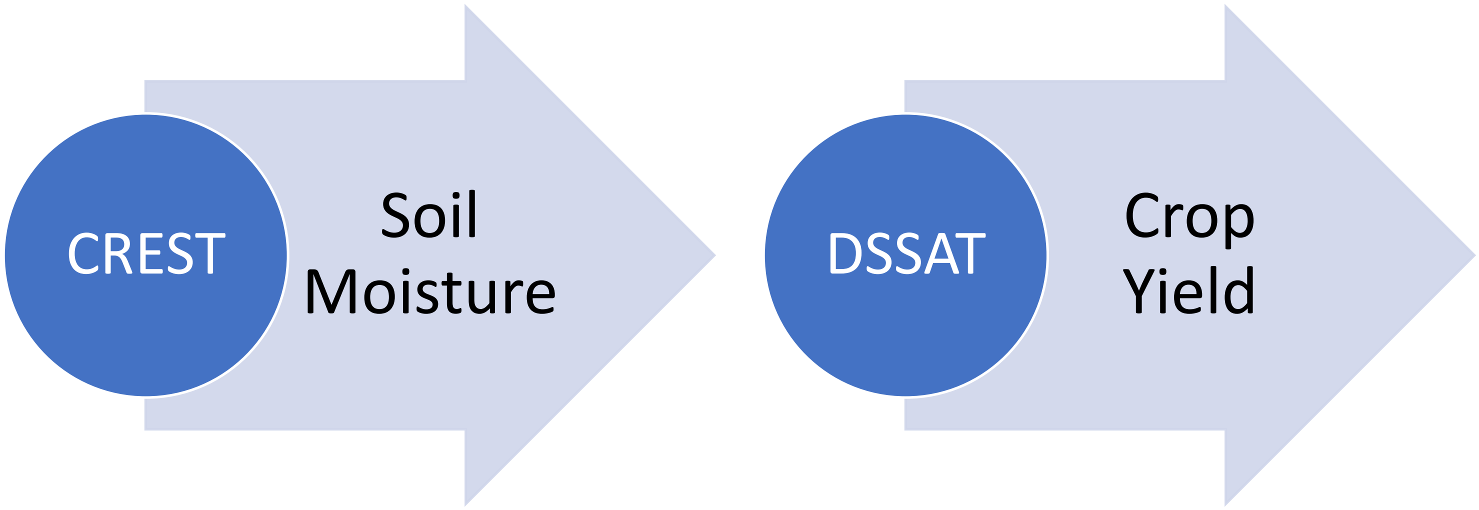
@ IPB

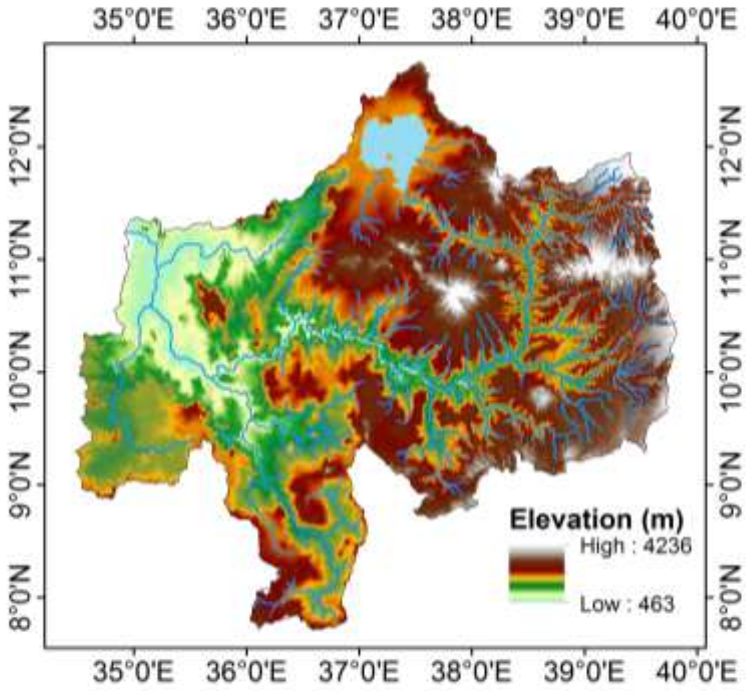
UCONN

by

Meijian Yang, Guiling Wang
Department of Civil & Environmental Engineering and
Center for Environmental Sciences and Engineering
University of Connecticut

Modeling Crop Yields in Dry Season

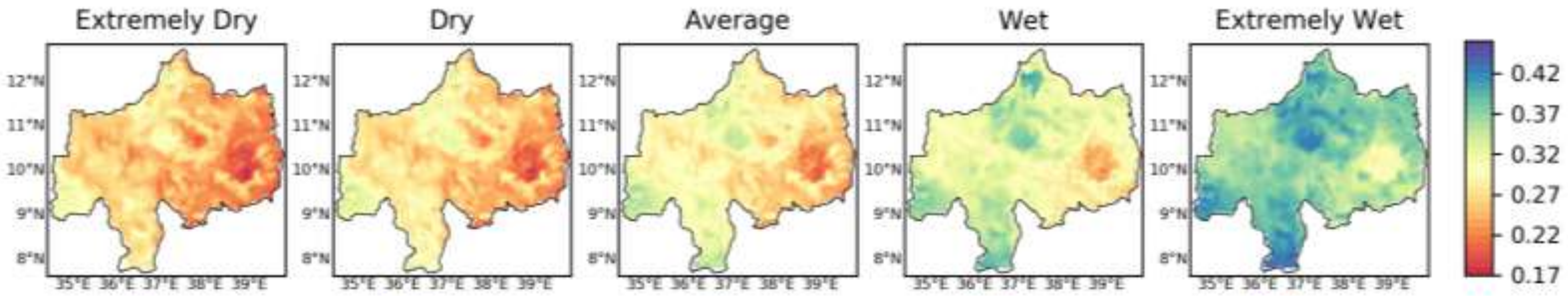




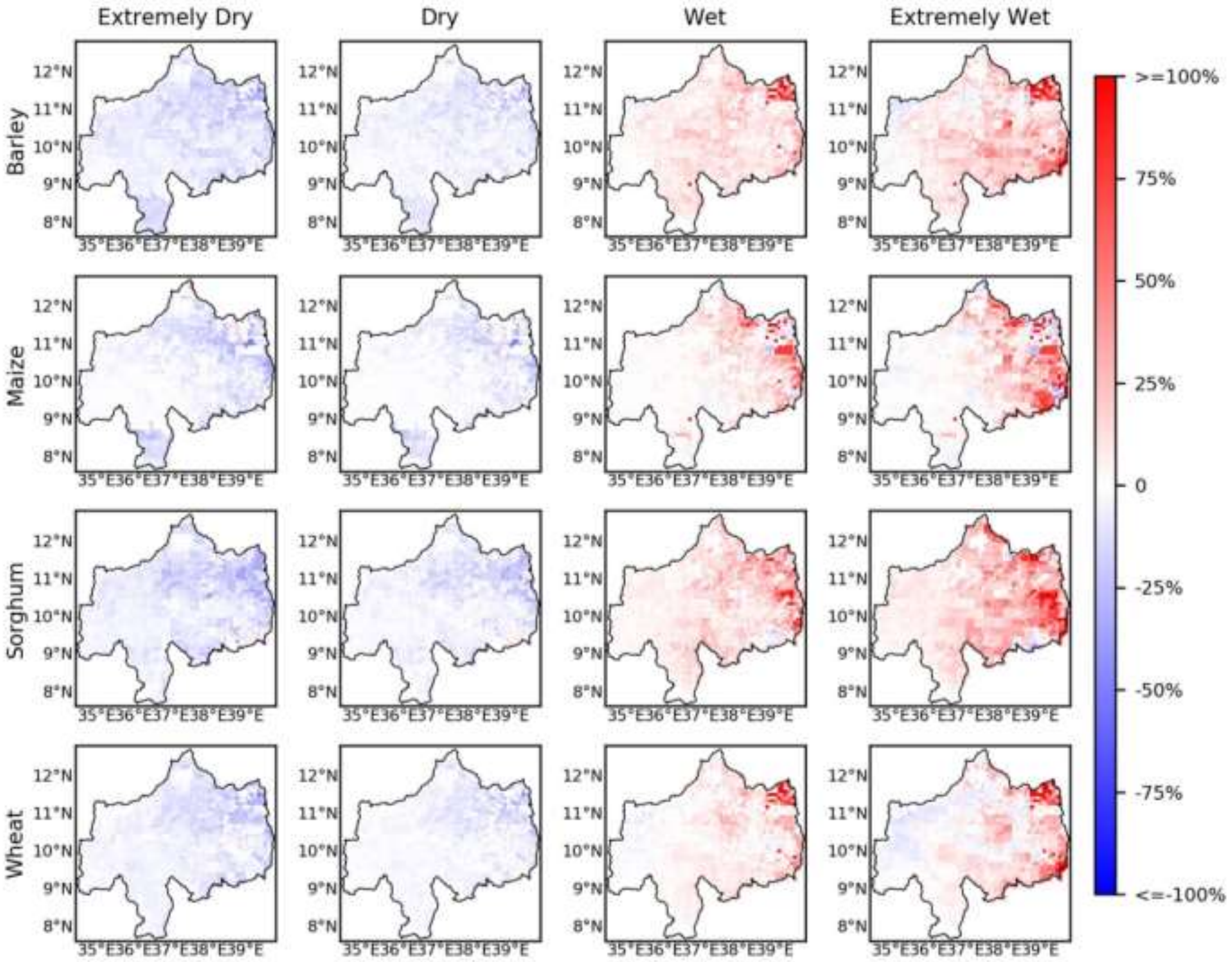
Pre-season soil moisture classification

Classification	Criteria
Extremely Dry	10th percentile
Dry	25th percentile
Normal	50th percentile
Wet	75th percentile
Extremely Wet	90th percentile

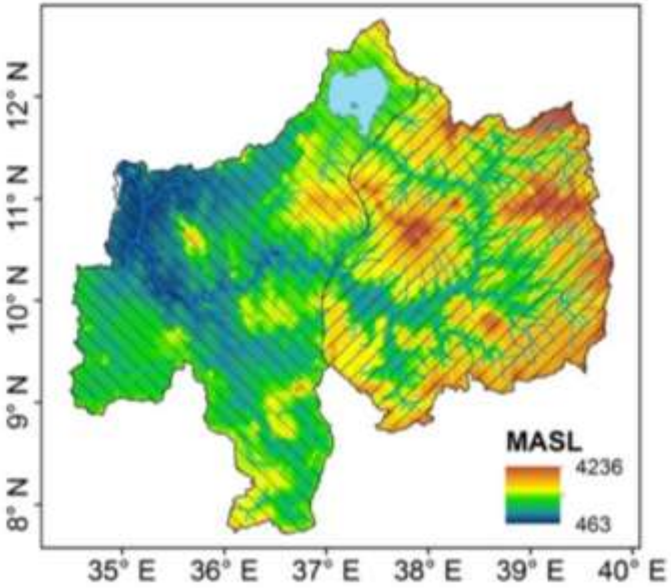
Soil moisture classification and distribution



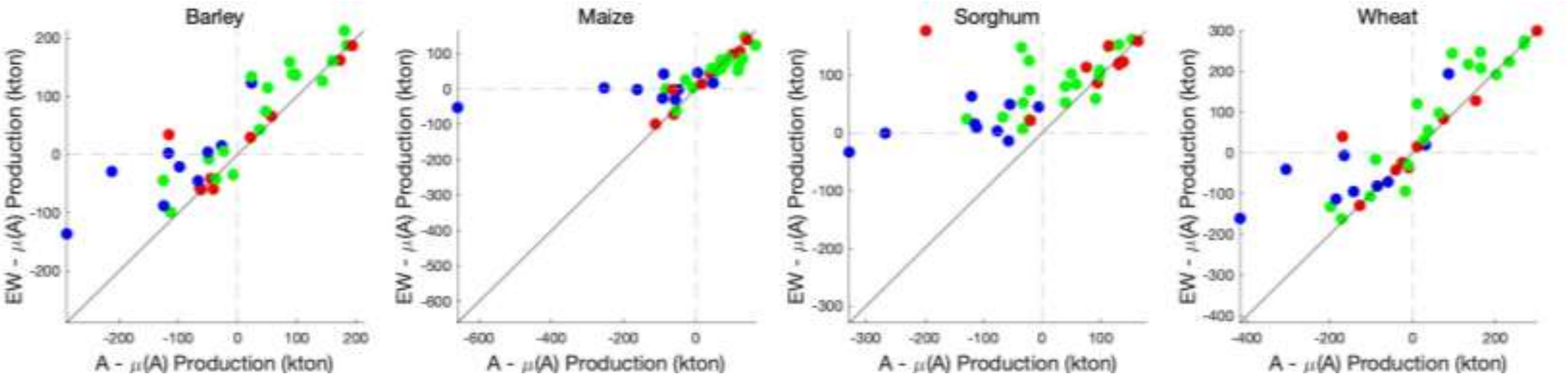
Yield relative difference to normal condition



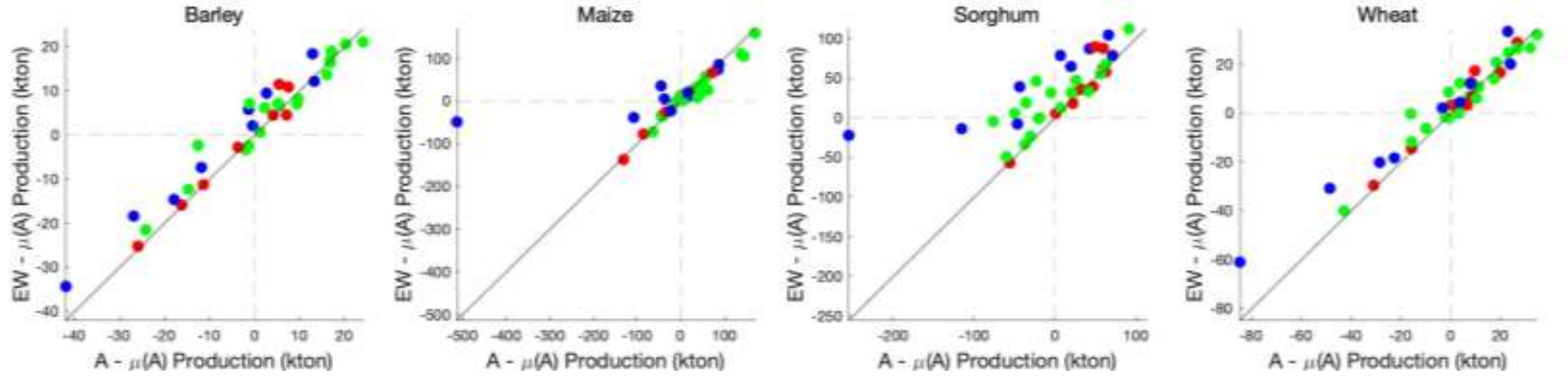
Basin division



East basin

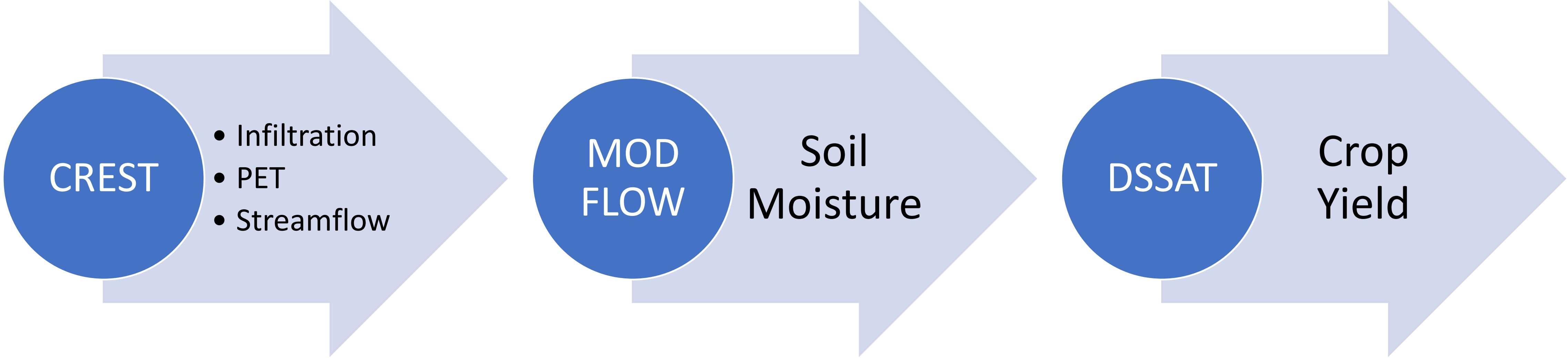


West basin



- Dry year
- Normal year
- Wet year

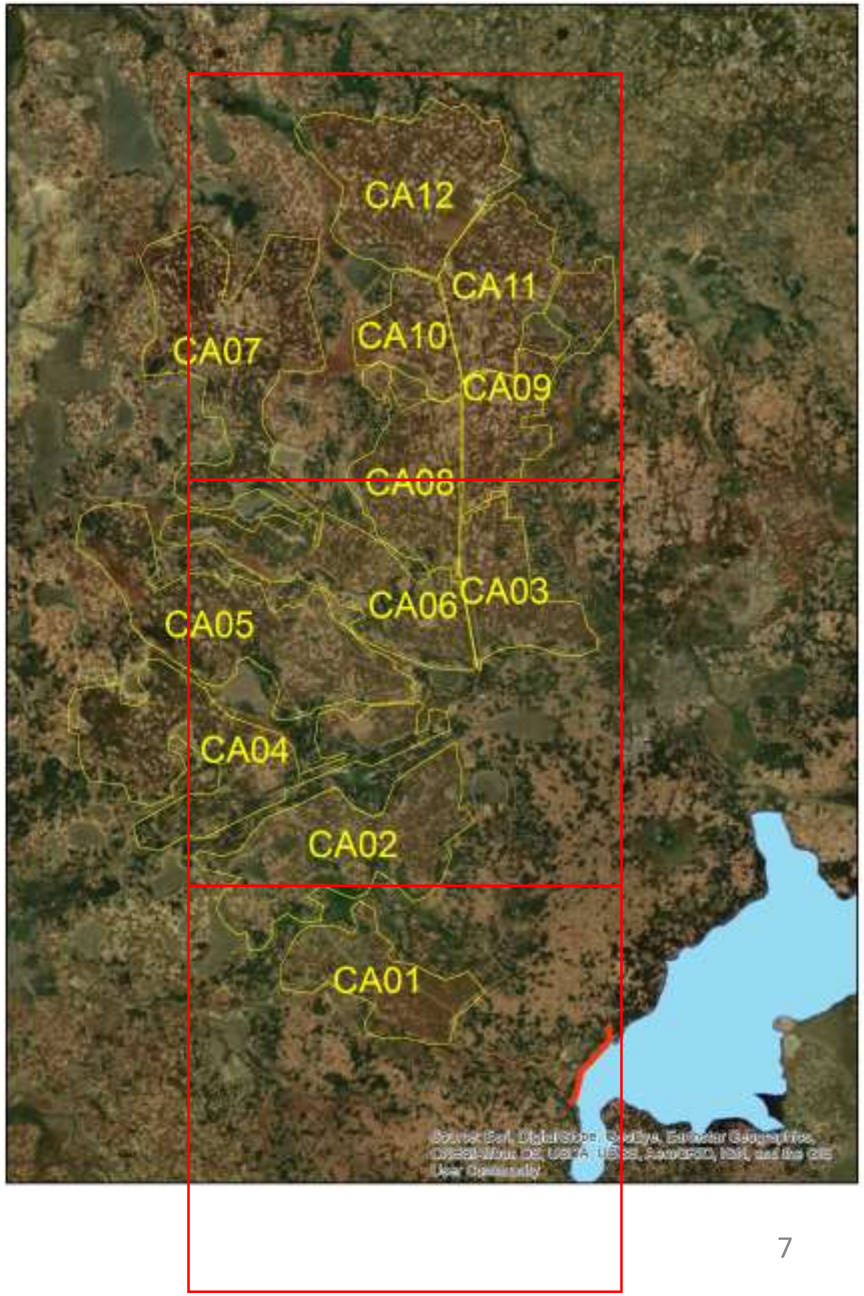
Modeling Crop Yields in Dry Season

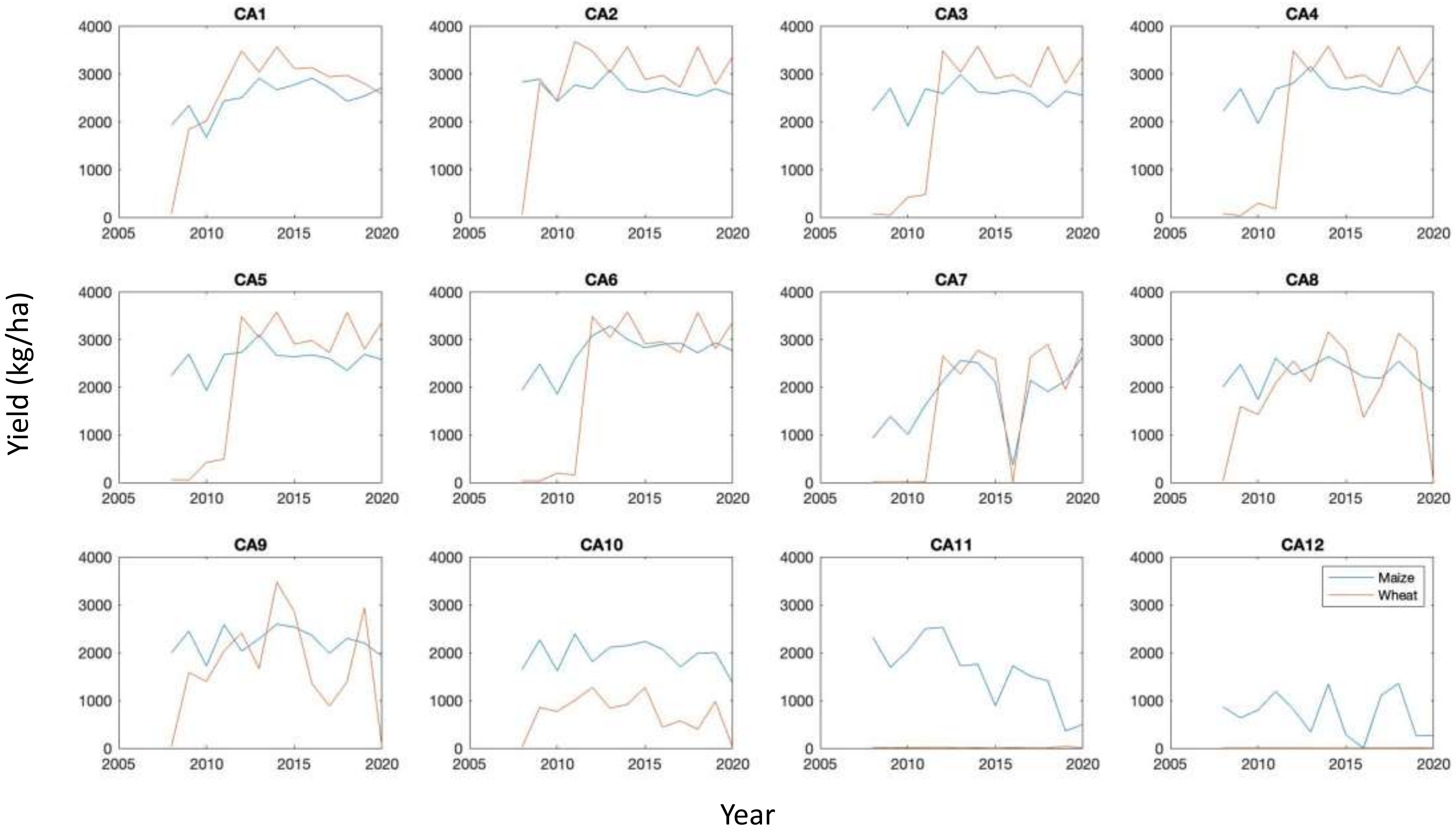


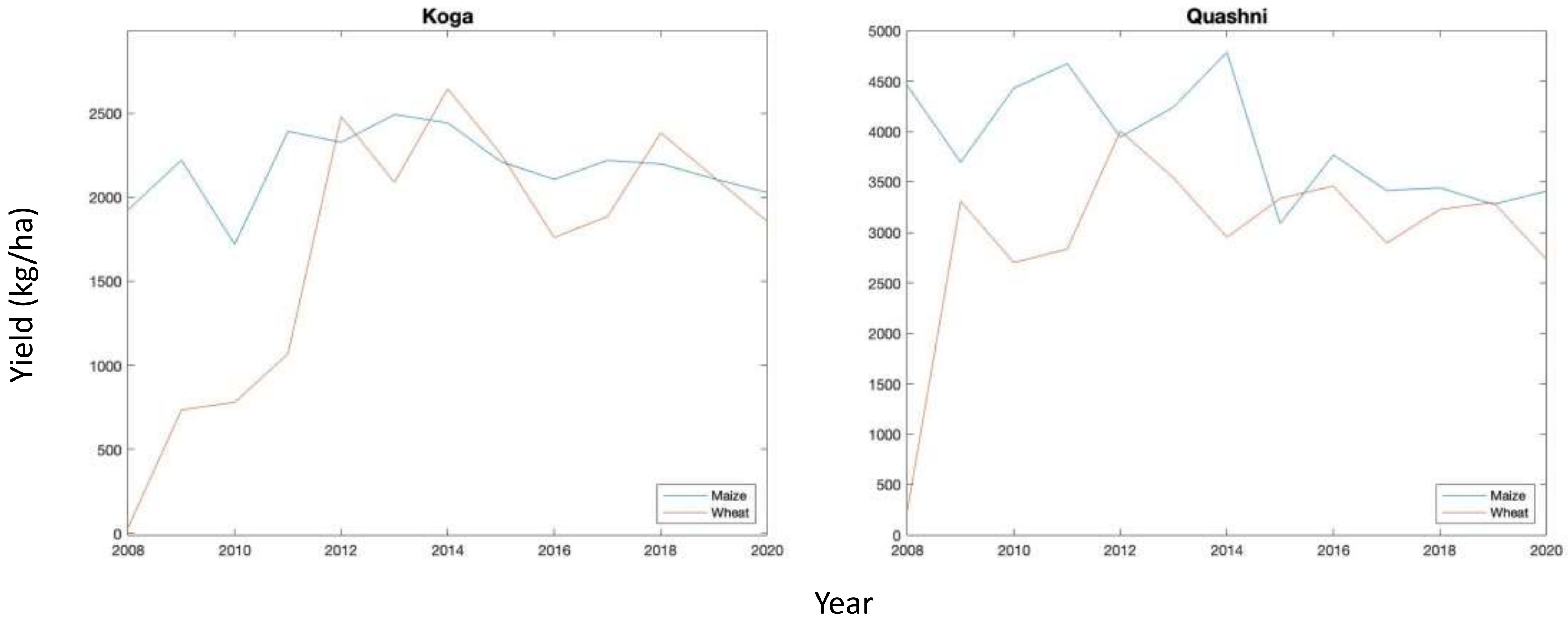
Forcing:
MSWEP, ECMWF (2008-2014)
GDAS, IMERG (2015- Aug. 15 2019)
CFS_50thPercentile (Aug. 15 2019 – Feb. 29 2020)

Crop types and planting time

Maize (January 15)
Wheat (December 15)
(Source: Berihun’s survey and Mamaru’s report)




CA1
CA2
CA3
CA4
CA5
CA6
CA7
CA8
CA9
CA10
CA11
CA12
Maize
Wheat
Yield (kg/ha)
Year


Koga
Quashni
Maize
Wheat
Maize
Wheat
0
500
1000
1500
2000
2500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
2008
2010
2012
2014
2016
2018
2020
2008
2010
2012
2014
2016
2018
2020
Yield (kg/ha)
Year

Correlation Coefficients between climate variables and crop yields

	Maize				Wheat			
	SR	**Tmax**	**Tmin**	**SM**	**SR**	**Tmax**	**Tmin**	**SM**
CA1	0.475	0.557	-0.410	0.635	0.274	0.320	-0.152	0.613
CA2	-0.394	-0.316	0.157	-0.234	0.197	0.175	0.137	0.308
CA3	0.052	0.179	-0.012	0.339	0.568	0.496	-0.095	0.907
CA4	0.153	0.203	0.081	0.282	0.574	0.505	-0.094	0.890
CA5	0.056	0.167	0.021	0.367	0.567	0.496	-0.095	0.897
CA6	0.331	0.370	-0.029	0.796	0.575	0.506	-0.093	0.921
CA7	0.128	0.092	0.153	0.881	0.462	0.377	0.096	0.953
CA8	-0.144	-0.170	-0.053	0.533	0.022	0.067	0.270	0.713
CA9	-0.135	-0.089	-0.055	0.492	-0.230	-0.092	0.211	0.751
CA10	-0.274	-0.174	0.087	0.598	-0.291	-0.151	0.127	0.648
CA11	-0.658	-0.759	-0.552	0.684	-0.070	0.062	0.481	0.254
CA12	-0.342	-0.518	-0.314	0.604	0.028	0.054	0.337	0.350
Quashni	-0.624	-0.880	-0.356	0.370	0.277	0.339	0.279	-0.785

Significant at 0.1, 0.05, 0.01 levels

Summary

- In wet season, irrigate the soil at planting time can notably improve crop yields, especially in east Blue Nile basin.

- In dry season, soil moisture is the key factor that affects crop yields. Wheat has higher soil moisture sensitivity than maize.

Future work

- Model 2 representative vegetables - cabbage and pepper in dry season

- Write a paper regarding seasonal crop yield forecast

CREST Simulation Results in Upper Blue Nile Basin For Bulletin 2019

Rehenuma Lazin
Department of Civil and Environmental Engineering
University of Connecticut

Forcing Datasets

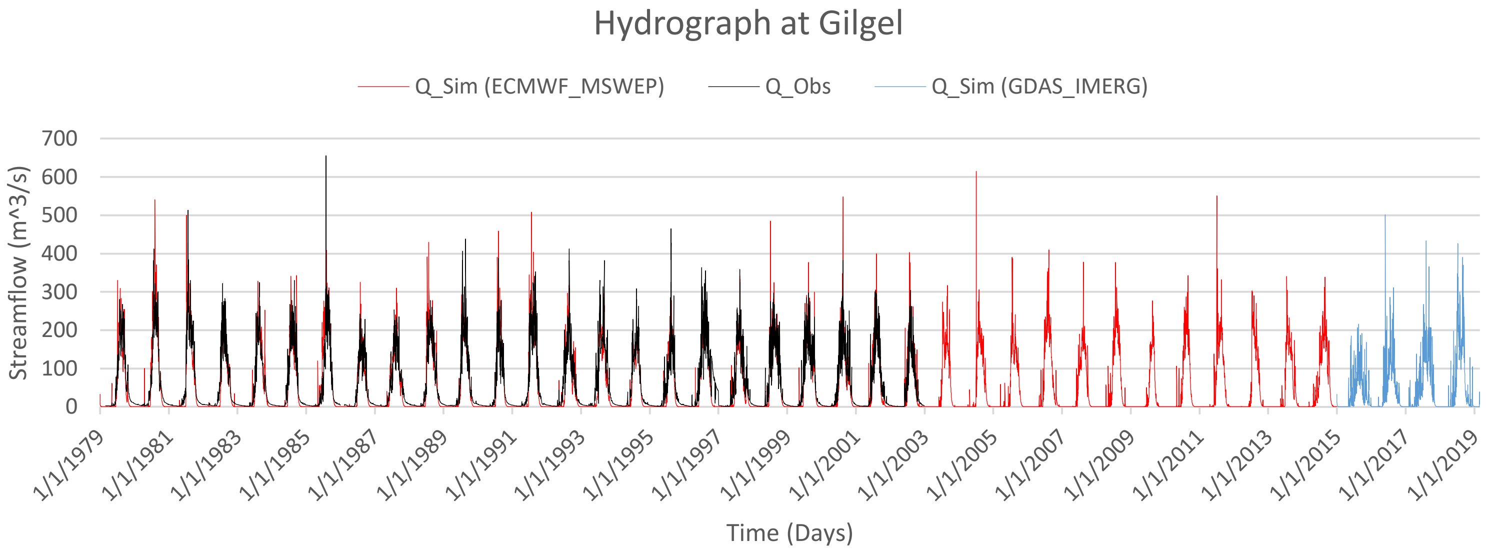
Forcing Variables
Precipitation
Air Temperature
Pressure
Specific Humidity
Shortwave Radiation
Longwave Radiation
Wind Speed

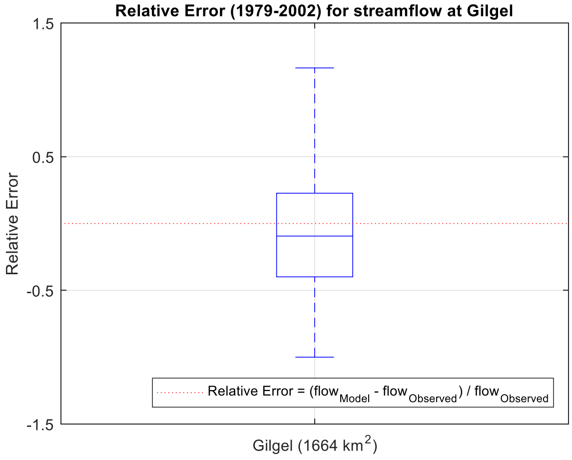
Temporal Extent	Source	Spatial Resolution	Temporal Resolution
1979-2014	ECMWF & MSWEP v1	0.25°	3 hourly
2015 – 2019 March	GDAS and IMERG	0.20° & 0.1°	3 hourly
2019 March – 2019 September	CFS (5%, 50%, 95% member)	Downscaled to 0.20°	Downscaled to 3 hourly, Precipitation-6 hourly

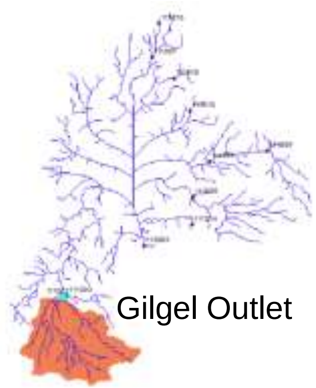
Simulation Outputs (Streamflow at Gilgel)

Simulation with Historic data

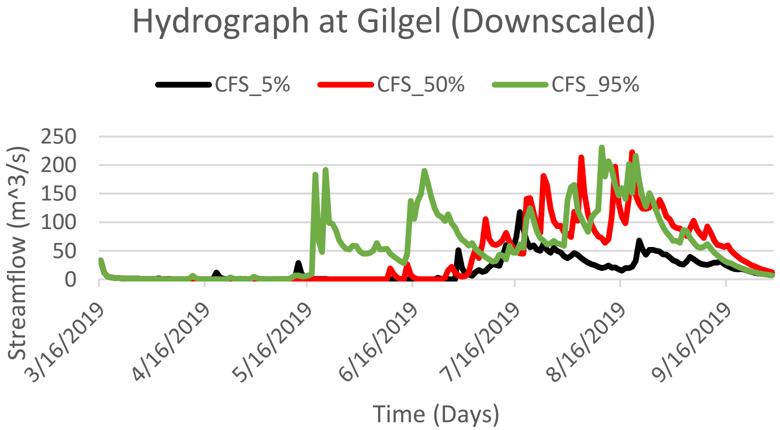
- 1979-2014 ECMWF and MSWEP forcings
- 2015-2019 March GDAS and IMERG forcings





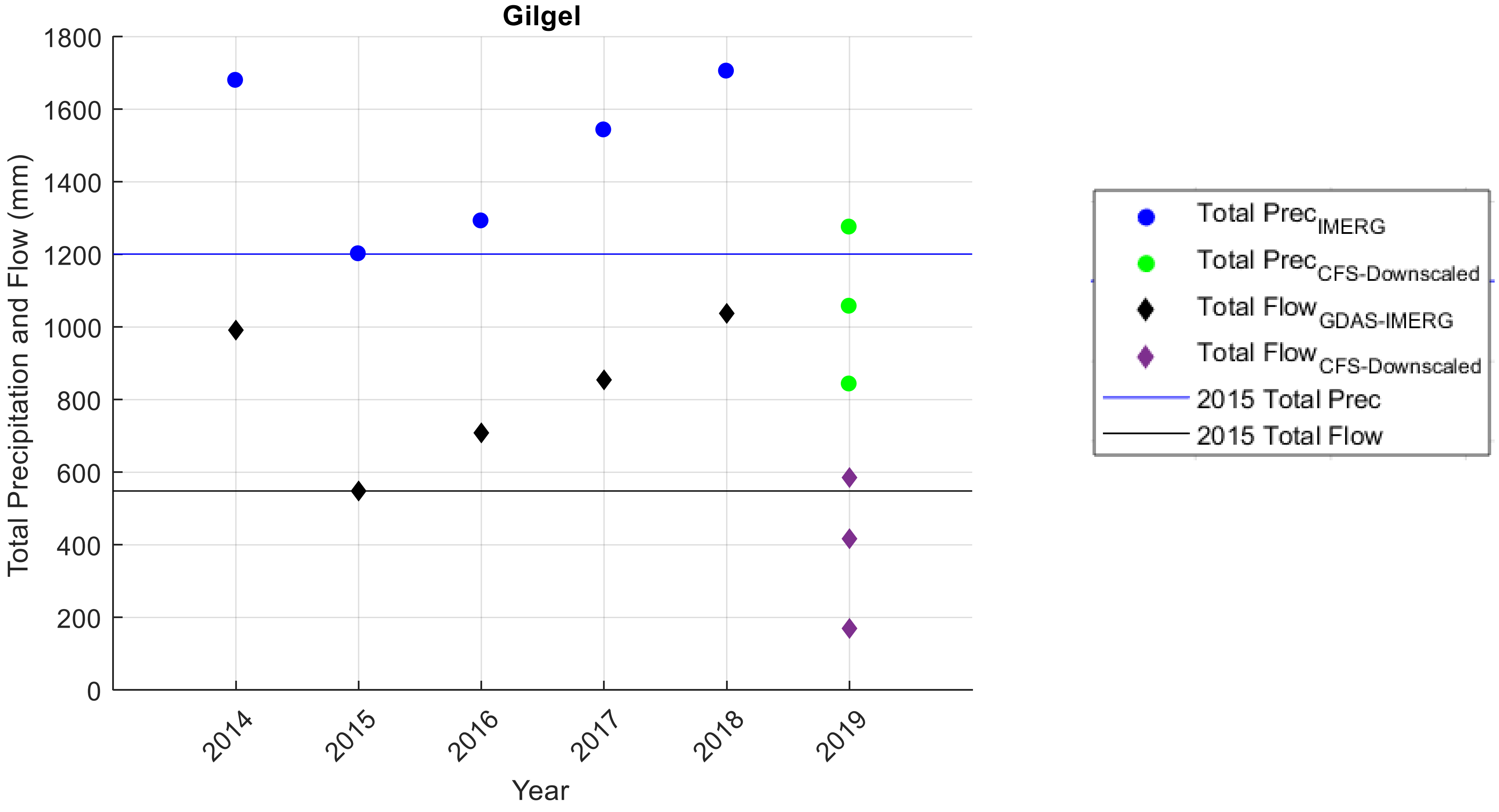


Simulation with CFS forecasted data for 2019

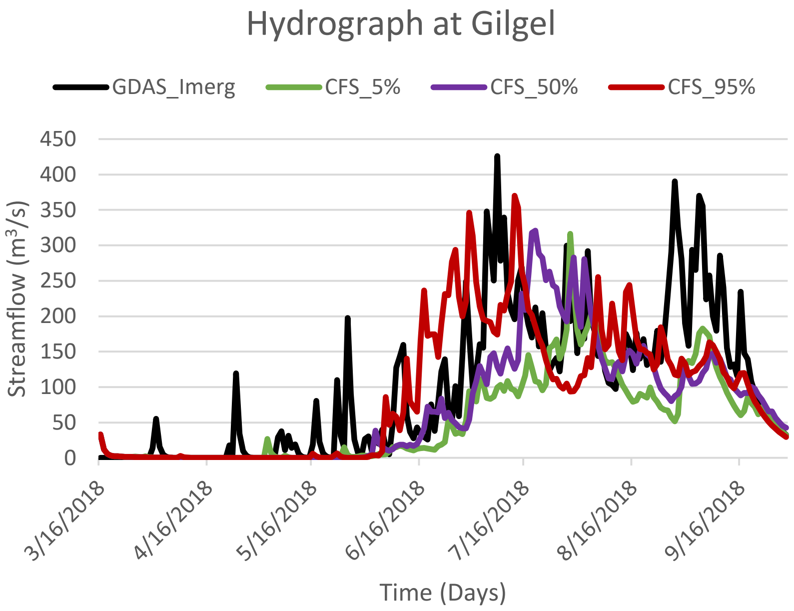


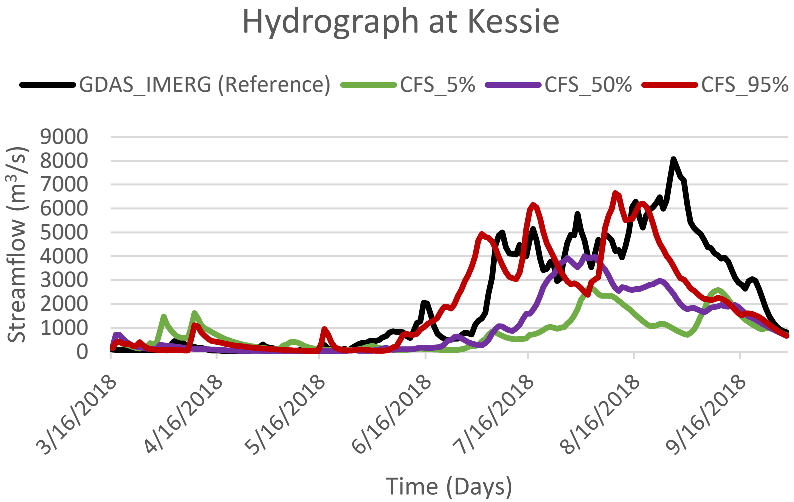
Total flow (mm) / Basin (km^2)	CFS 5%	CFS 50% (Median)	CFS 95%
Gilgel (1664 km^2)	169.412	416.361	585.069

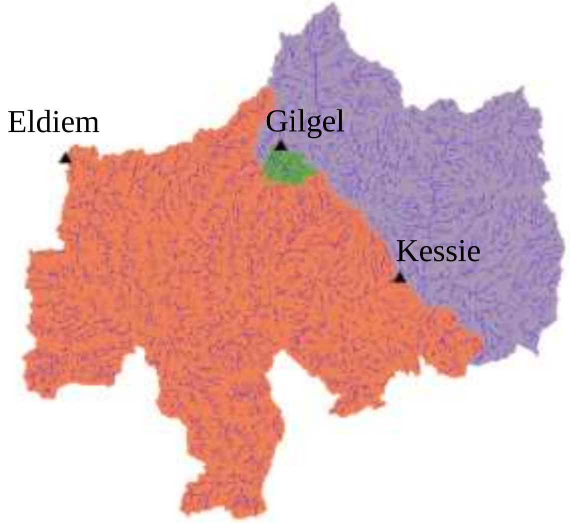
Comparison of Total Precipitation and Total flow

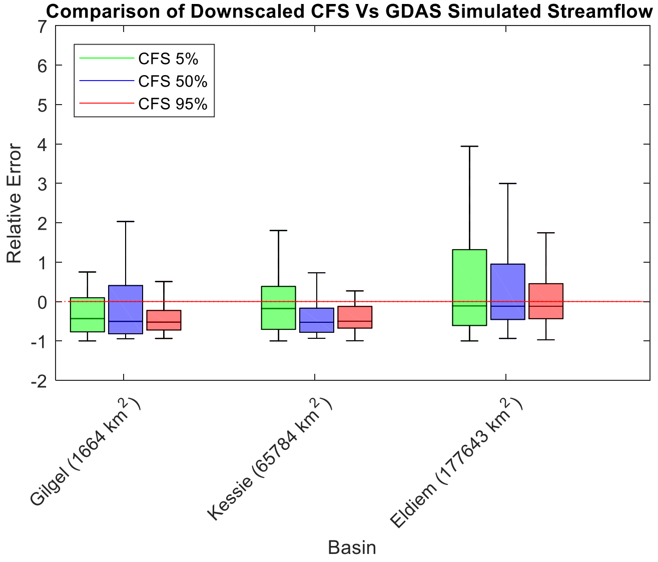


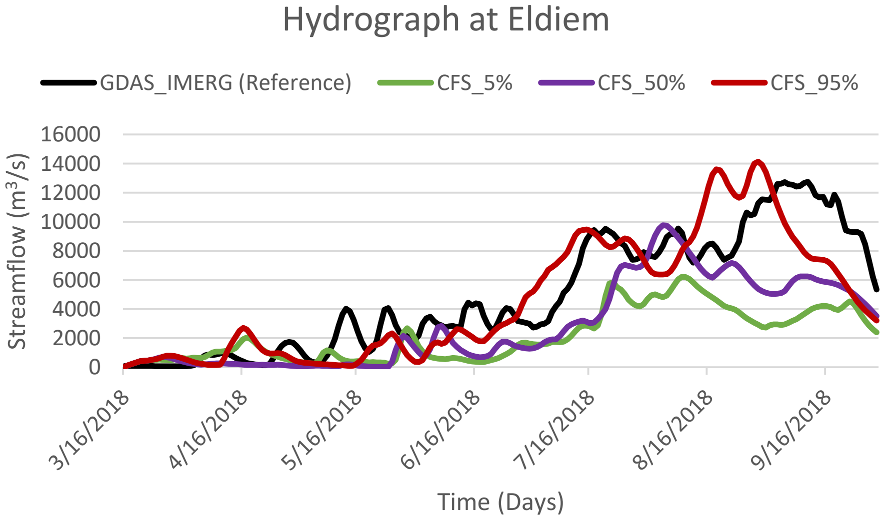
Dry Run 2018 to compare the performance CFS members



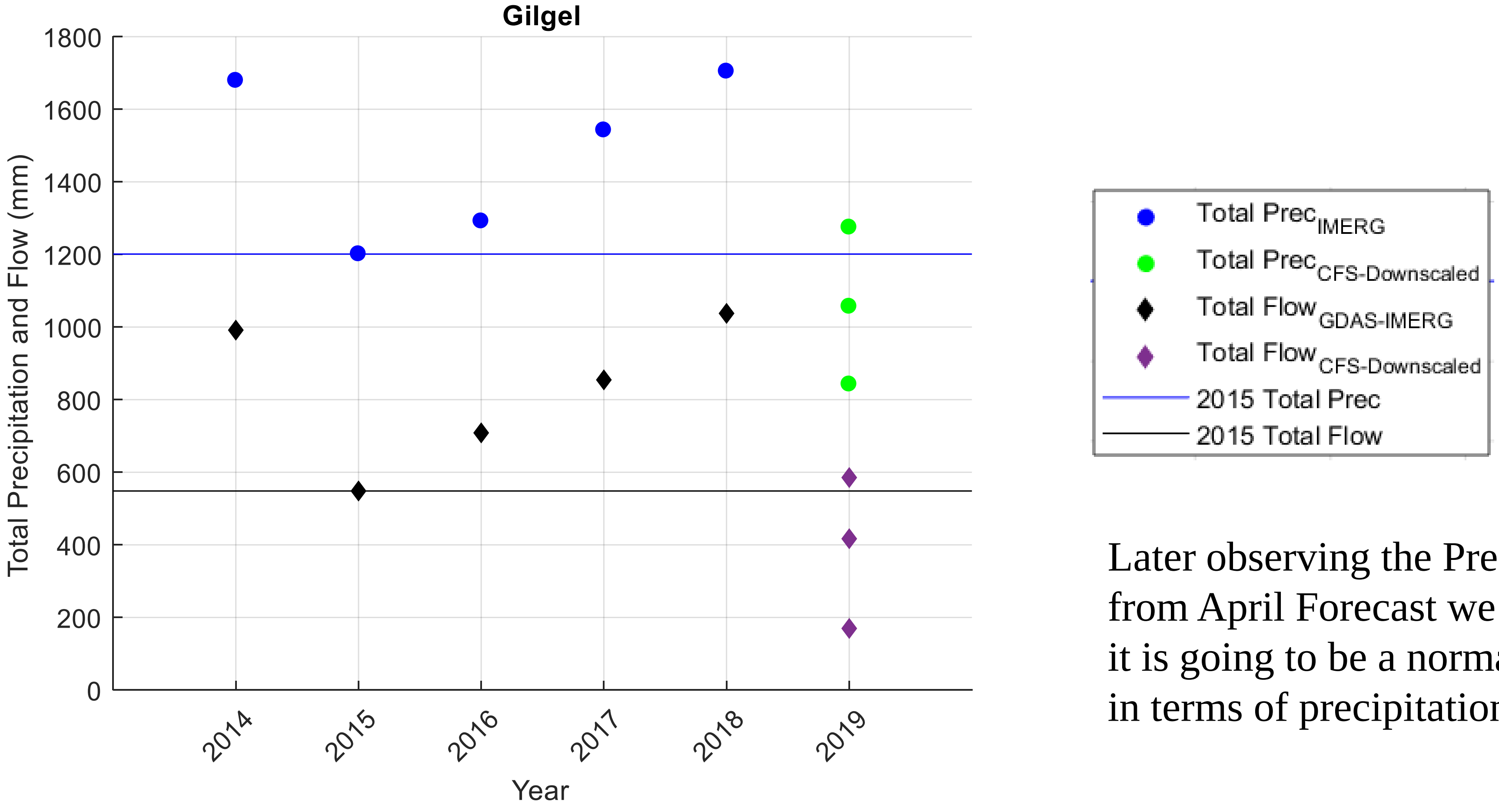






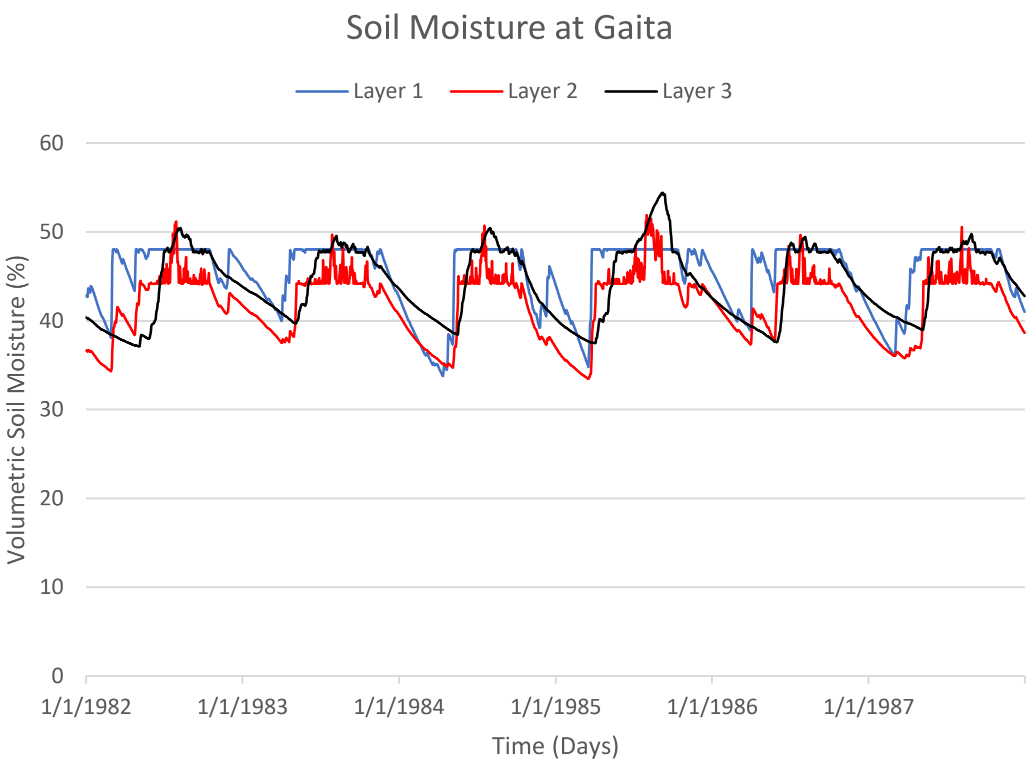


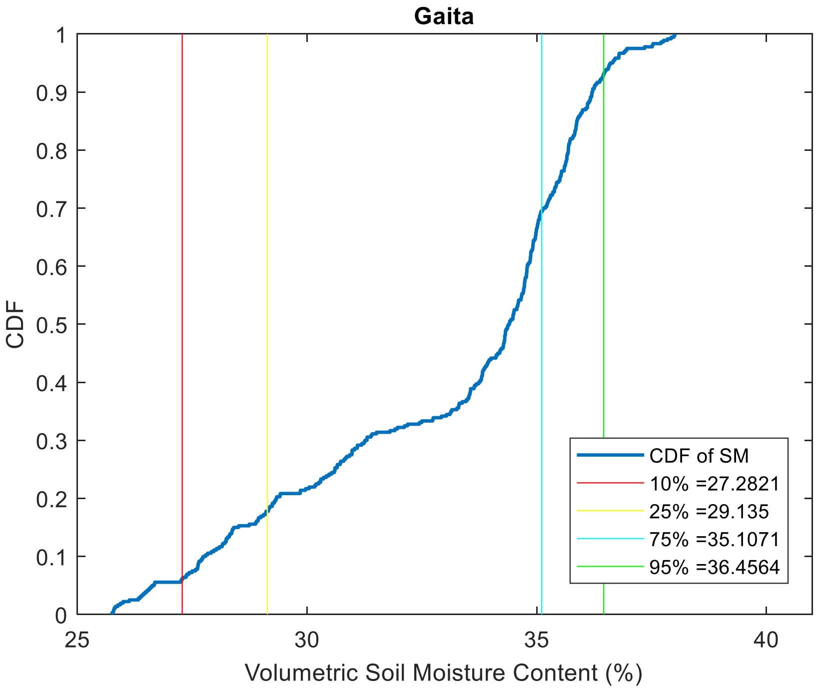
Comparison of Total Precipitation and Total flow



Later observing the Precipitation from April Forecast we concluded, it is going to be a normal condition in terms of precipitation and flow.

Simulation Outputs (Soil Moisture at Gaita)



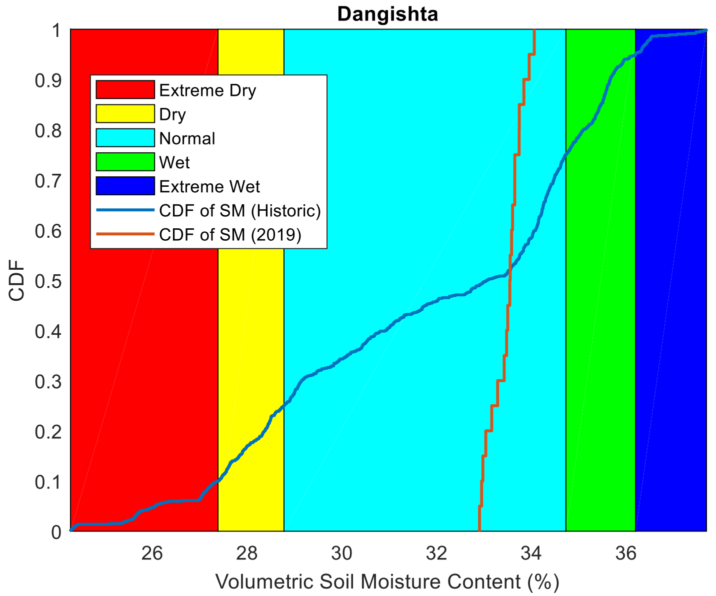


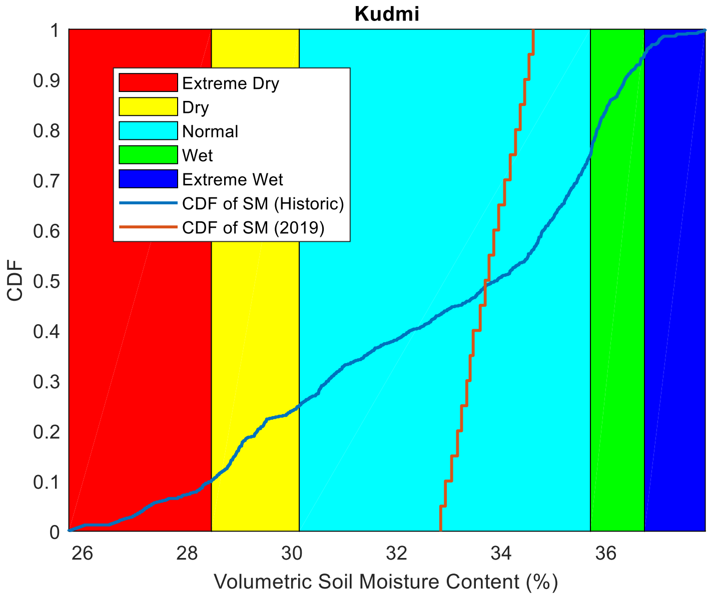
According to 1979-2014
(April 21- May 10)

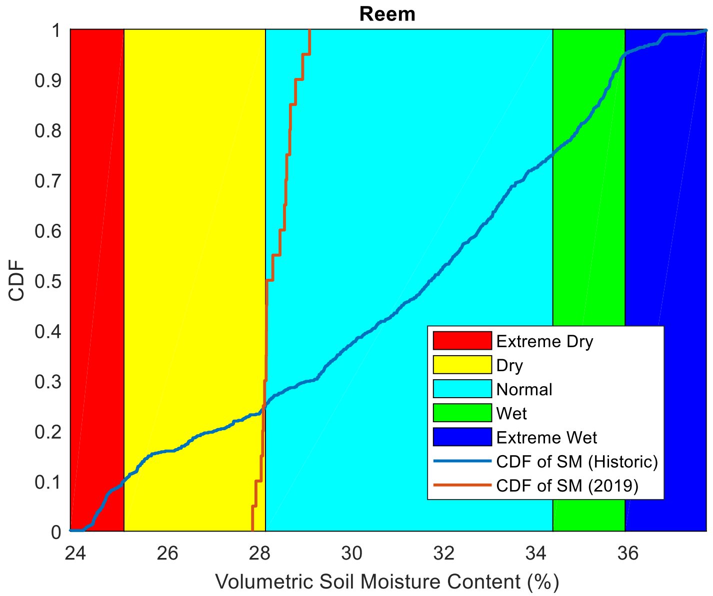
Layer 1: 0-10 cm
Layer 2: 10-40 cm
Layer 3: 40-190 cm

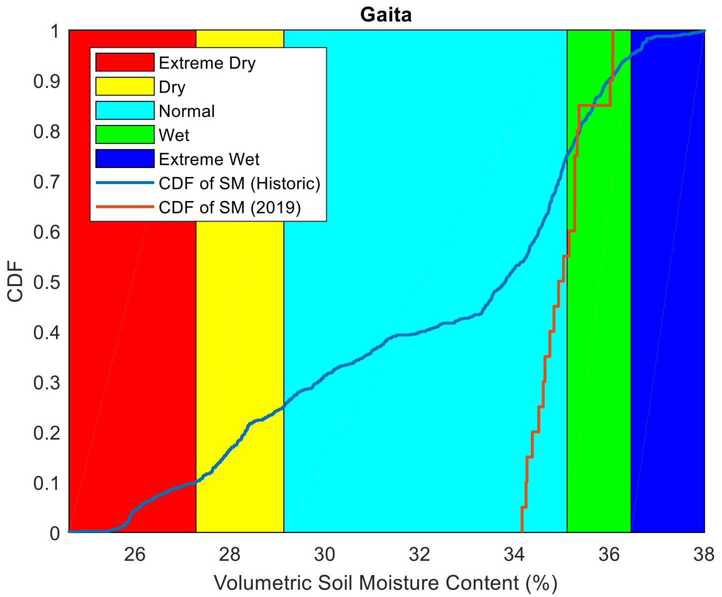
SM Condition	Volumetric SM range (%)
Extreme Dry (0-10%)	25.4 – 27.28
Dry (10-25%)	27.28 – 29.14
Normal (25-75%)	29.14 – 35.11
Wet (75-90%)	35.11 – 36.46
Extreme Wet (90-100%)	36.46 – 37.12

Soil Moisture Condition for **2019 (Downscaled CFS-95)**









Site Name	Soil Moisture Condition (2019)
Dangishta	Normal
Kudmi	Normal
Reem	Normal
Gaita	Wet

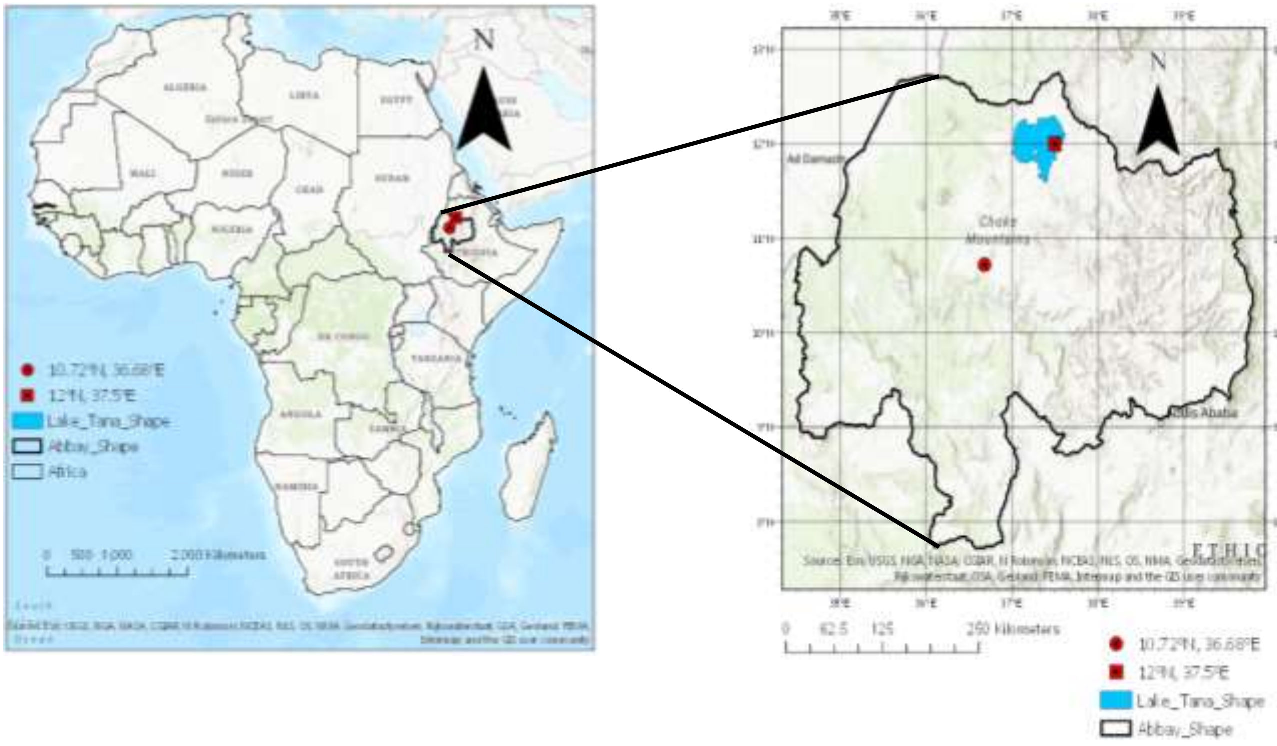
Thank you!

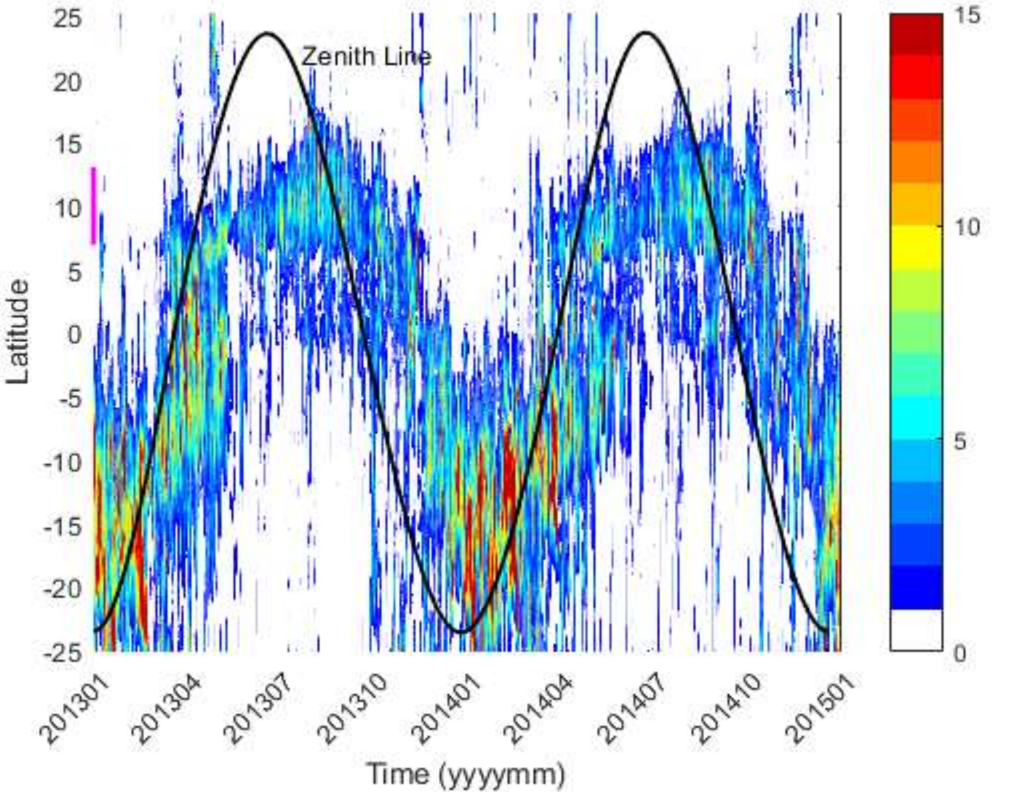
Seasonal Forecast: Post-processing of dynamical model output

Muhammad Rezaul Haider and M. Peña

- Climate drivers of precipitation
- Seasonal ensemble forecasts
    - Bias correction and spatial downscaling
    - Evaluation
- Highlights on dry season forecast of 2019-2020.

Study area and climatic drivers of precipitation





- ITCZ

Fig. 1: Hovmoller diagram for precipitation (mm/day). Daily time steps.

Forecast post-processing

- Forecast data
  - Bias
  - Resolution
- Training set
- Approaches:
  - Non-parametric
  - Parametric

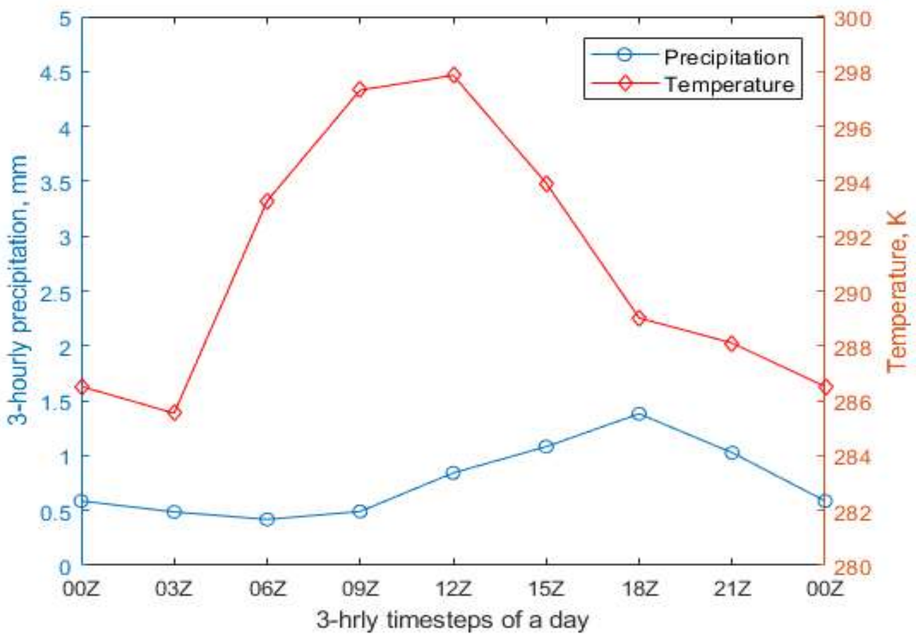


Fig. 2: Diurnal variability

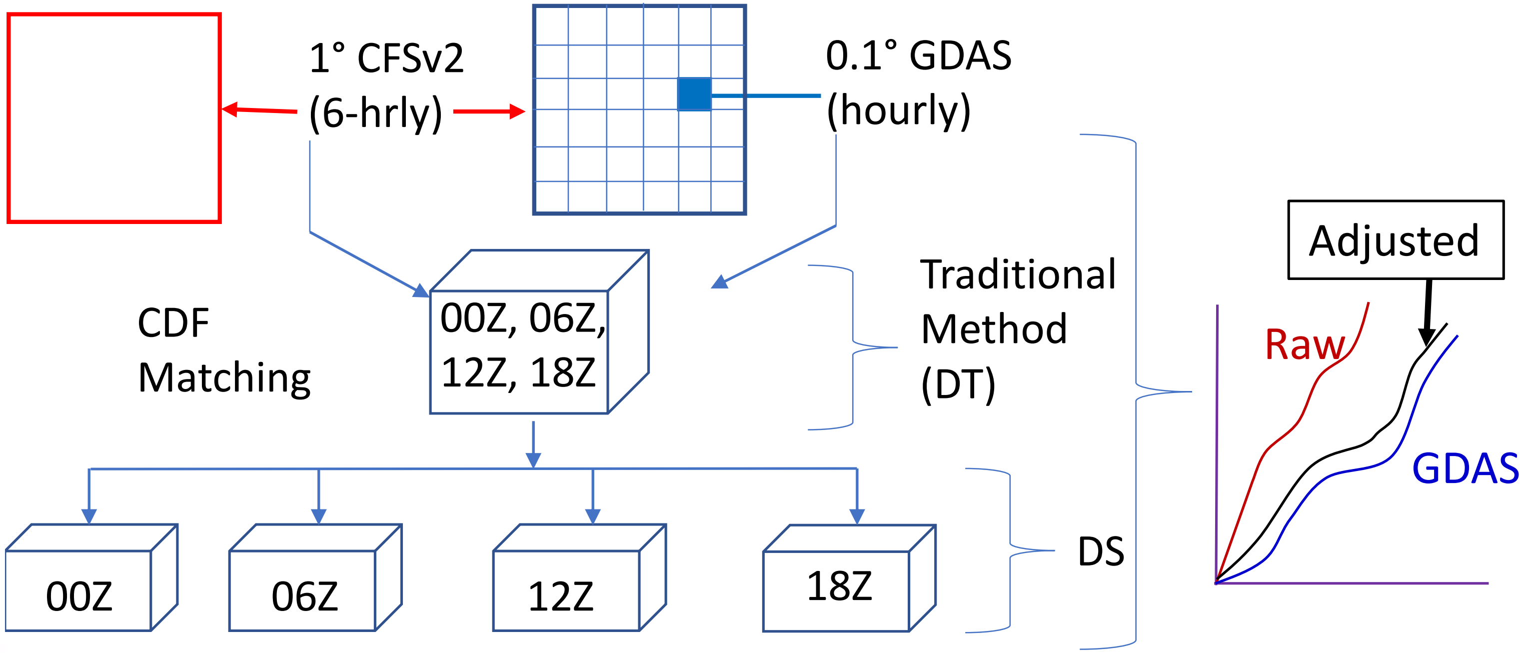


Fig. 3: Non-parametric approach (CDF matching)

Forecast post-processing

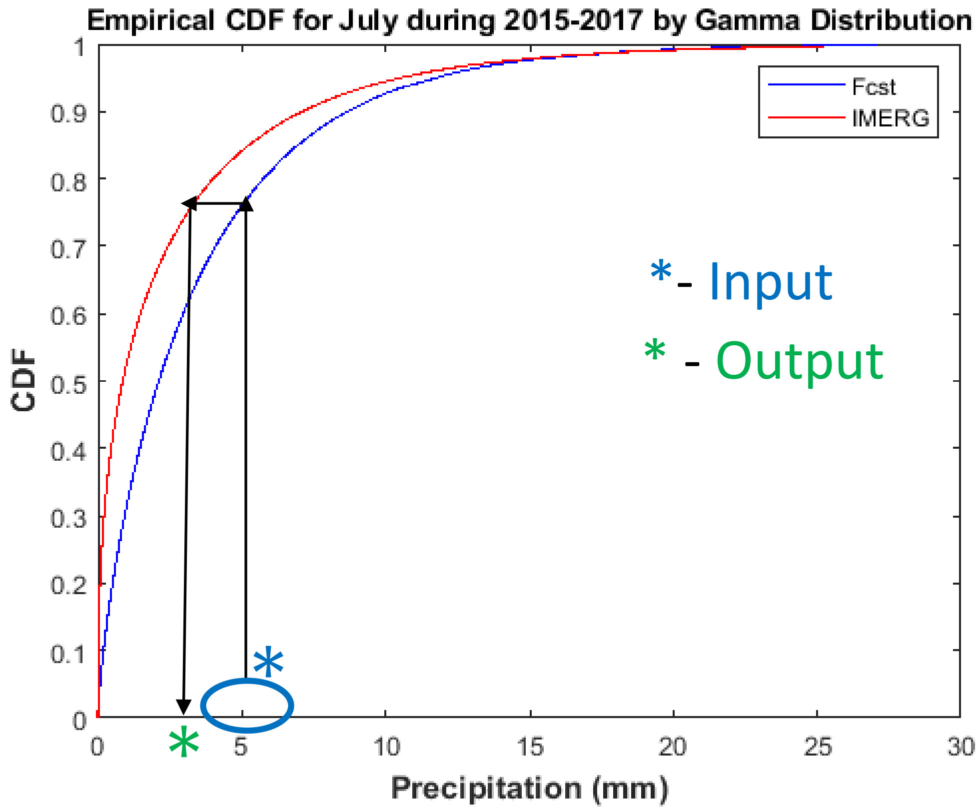
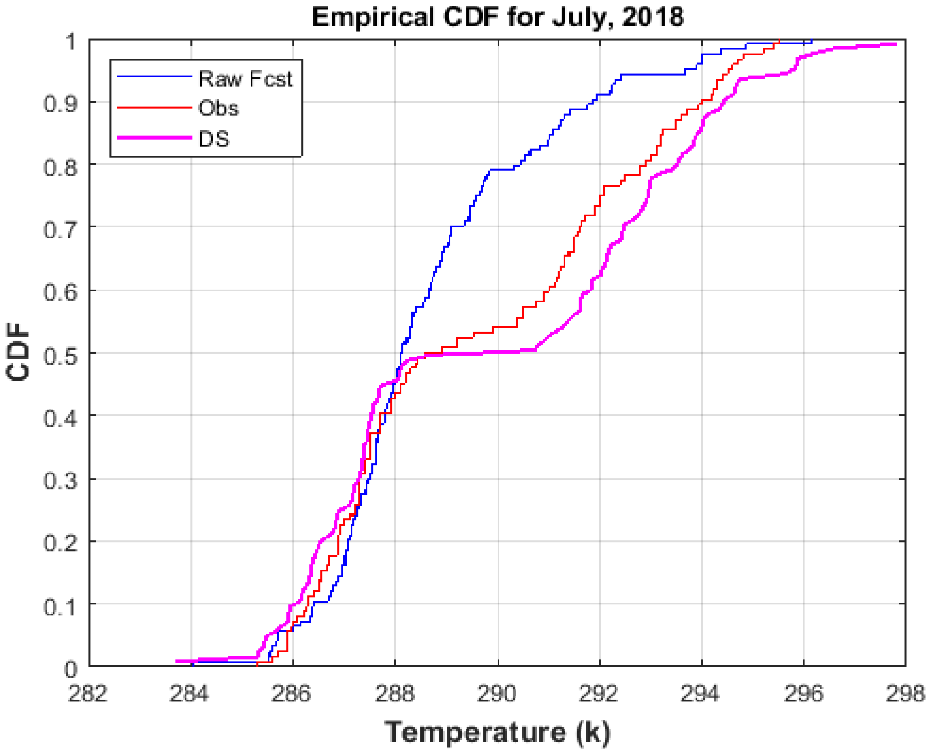


Fig. 4: Parametric approach (Distribution mapping, DM)

Some results for the wet season of 2018

Temperature bias correction.

Wet season of 2018



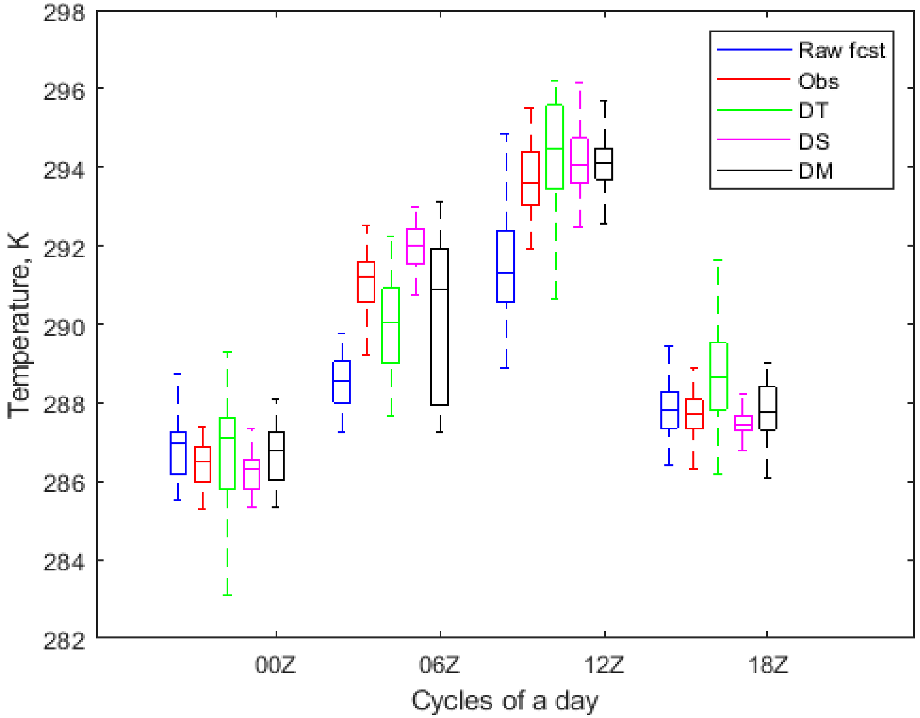
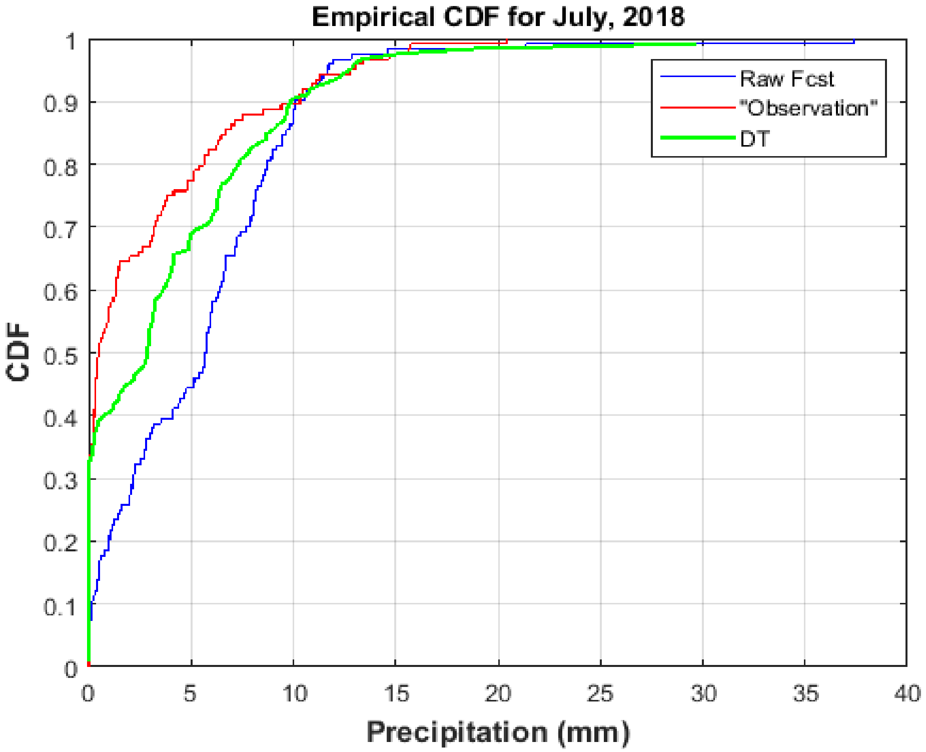


Fig. 5: Temperature bias correction by different methods.

Precipitation bias correction.

Wet season of 2018



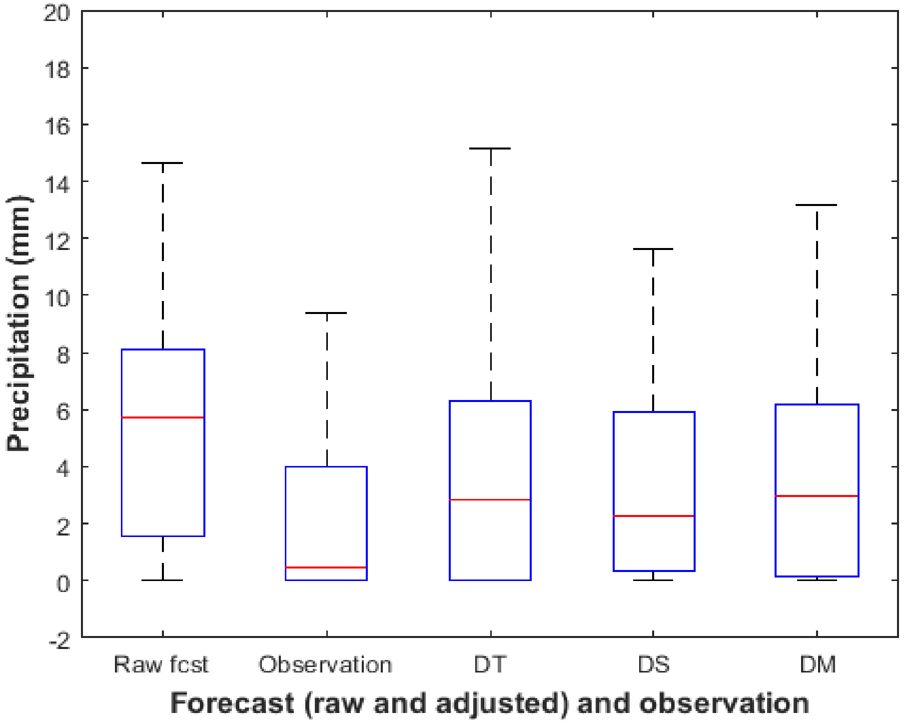


Fig. 6: Precipitation bias correction by different methods.

Summary Statistics

Wet season of 2018

Table 1: Temperature

Statistics	Forecast Type			
	Raw	DT	DS	DM
Bias (F)	-2.02	-0.58	**-0.40**	-0.64
RMSE (F)	3.19	2.93	**2.43**	2.88
Pearson Correlation	0.85	0.80	**0.88**	0.81

Table 2: Precipitation

Statistics	Forecast Type			
	Raw	DT	DS	DM
Bias (mm)	2.72	**1.07**	2.14	1.21
RMSE (mm)	6.67	**6.14**	8.95	6.67
Pearson Correlation	0.37	**0.38**	0.20	0.37

Spatial Downscaling (6 hr lead)

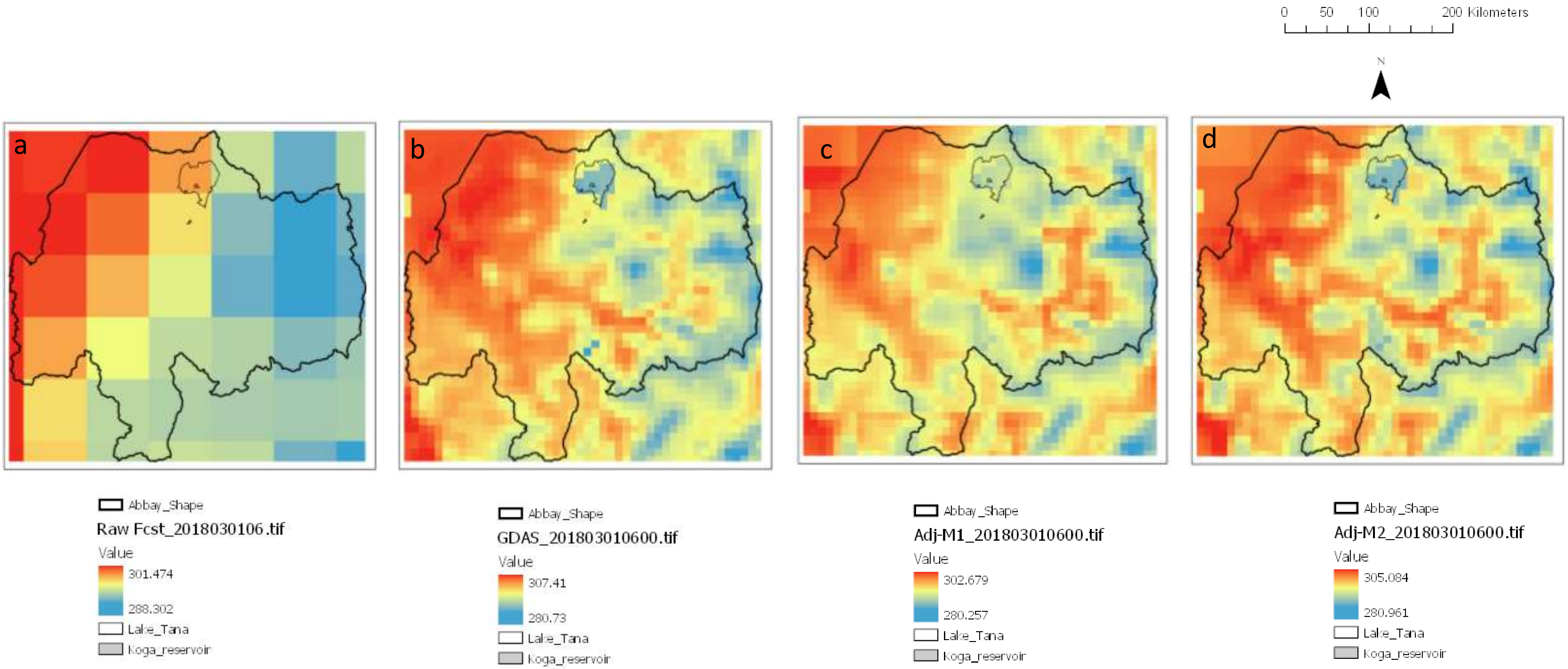


Fig. 7: Spatial pattern of temperature over BNB (**Raw, GDAS and bias corrected by two methods**)

Spatial Downscaling (7 Mon lead)

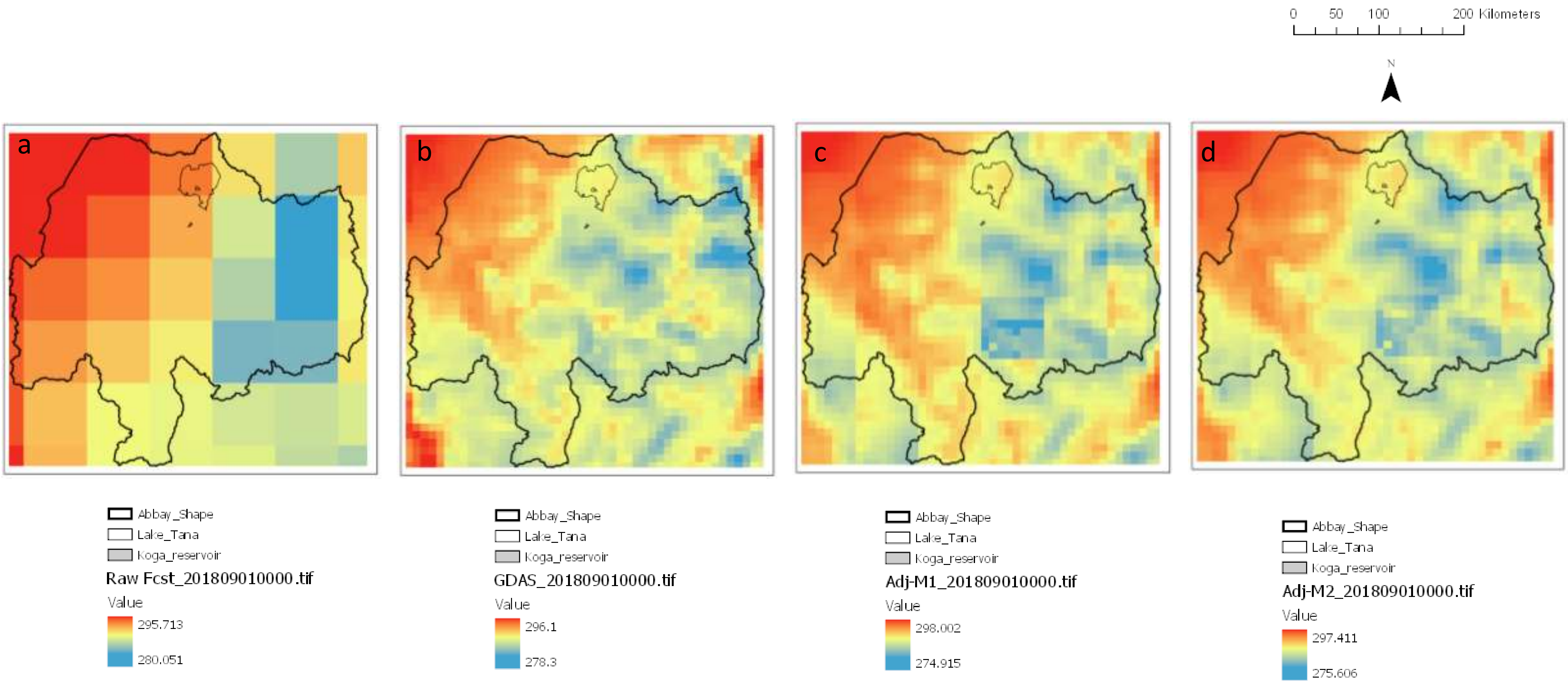
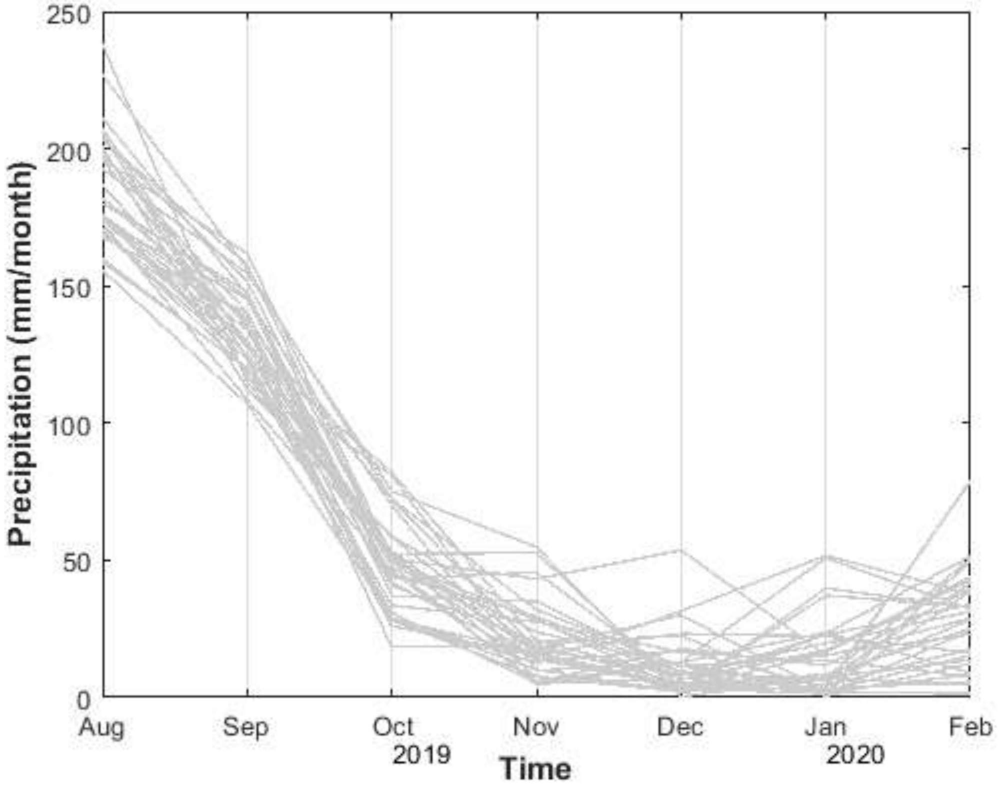


Fig. 8: Spatial pattern of temperature over BNB (**Raw, GDAS and bias corrected by two methods**)

Some highlights on dry season of 2019-2020.

Precipitation variability among forecast members



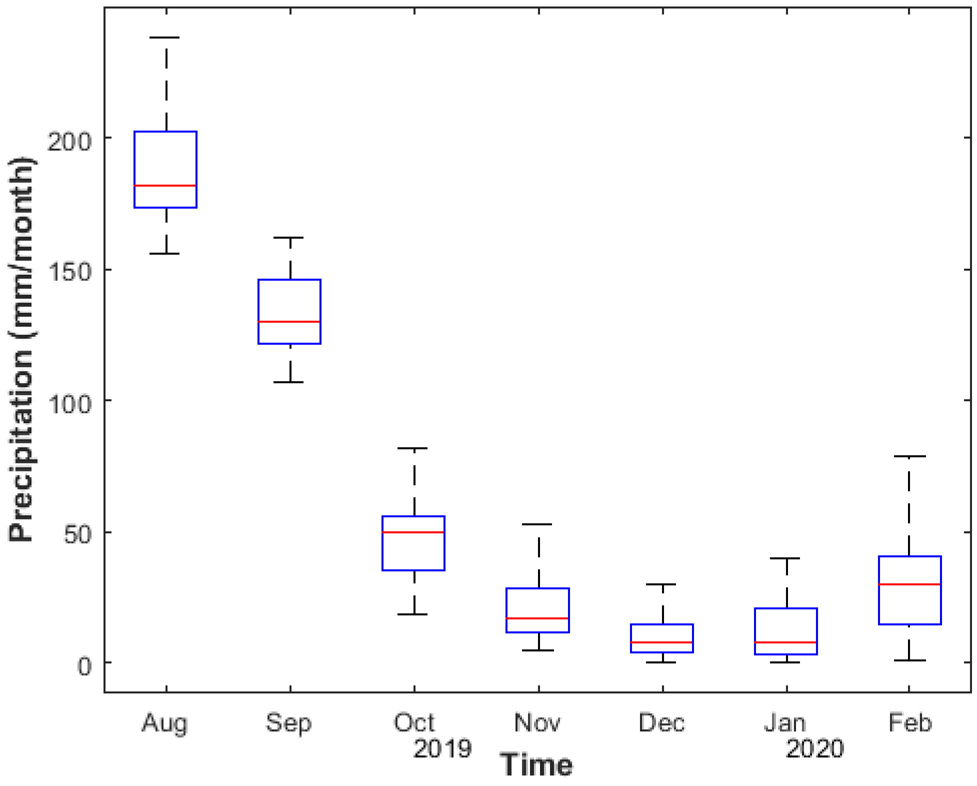
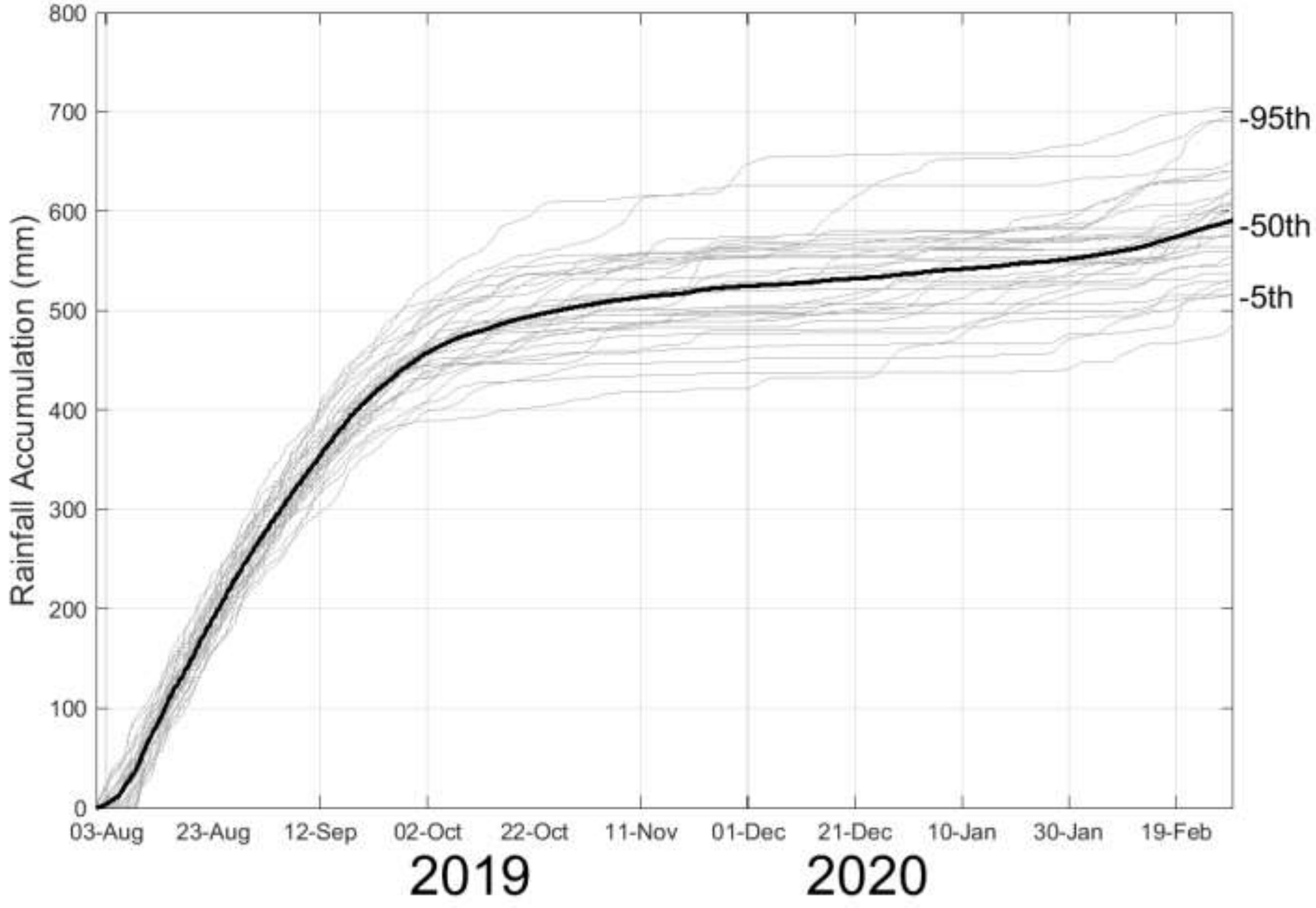


Fig. 9: Variability of monthly total precipitation among ensemble members.

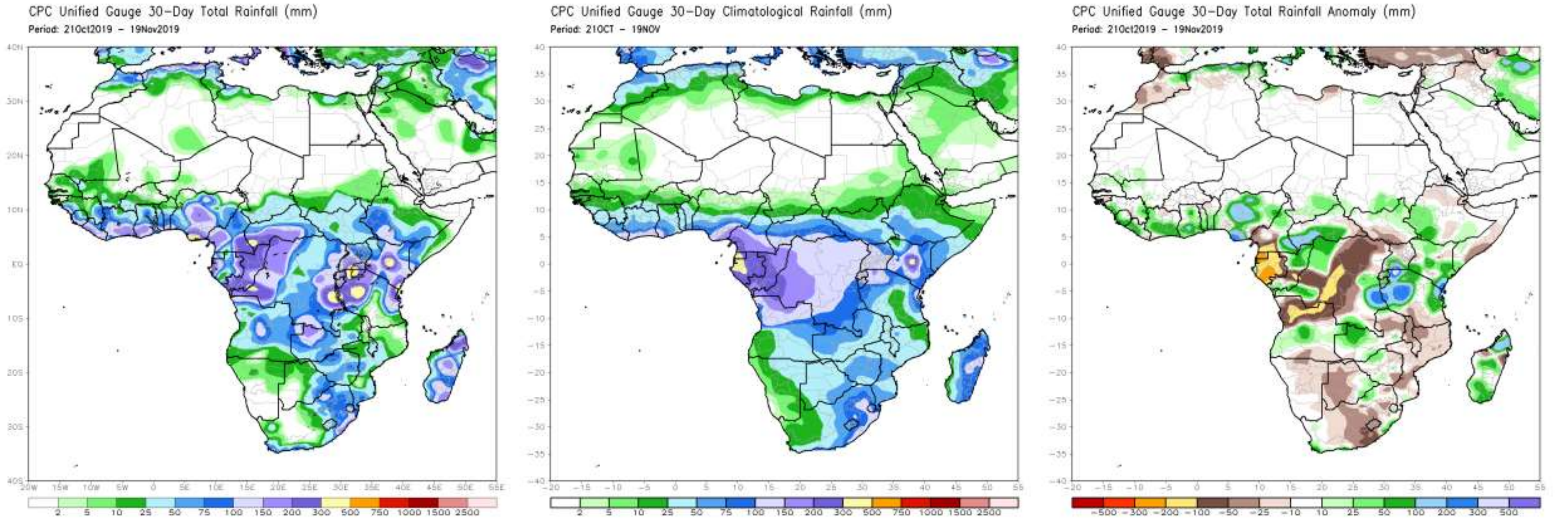
Accumulated precipitation and percentiles



Thanks Thymios
for the plot

Fig. 10: Accumulated precipitation with different percentiles.

Observed Precipitation



30-day total

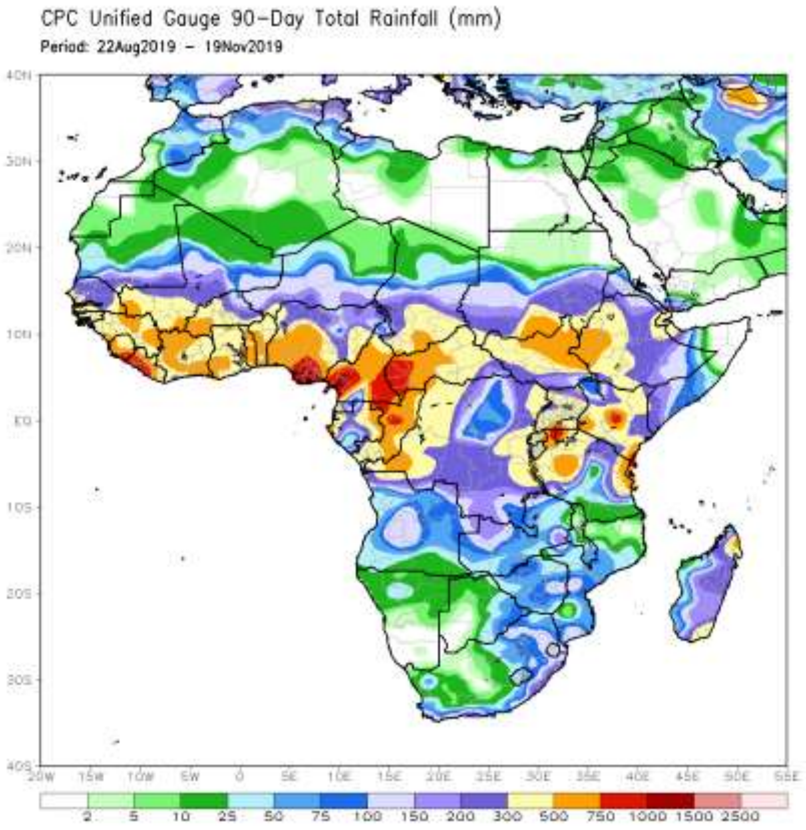
climatology

Anomaly

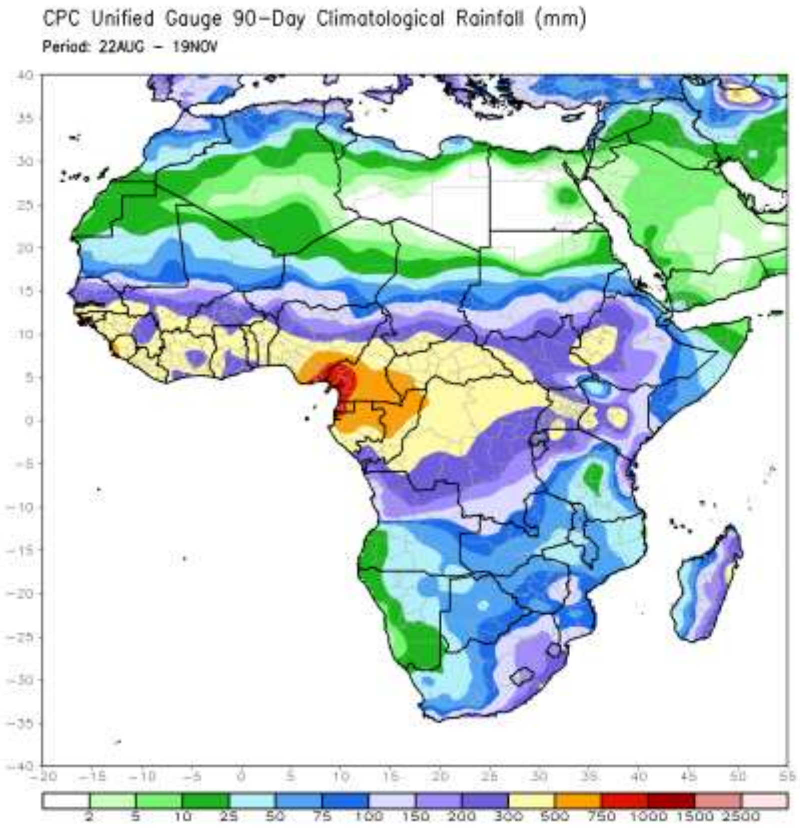
Fig. 11: 30-day precipitation total

https://www.cpc.ncep.noaa.gov/products/international/africa/africa.shtml

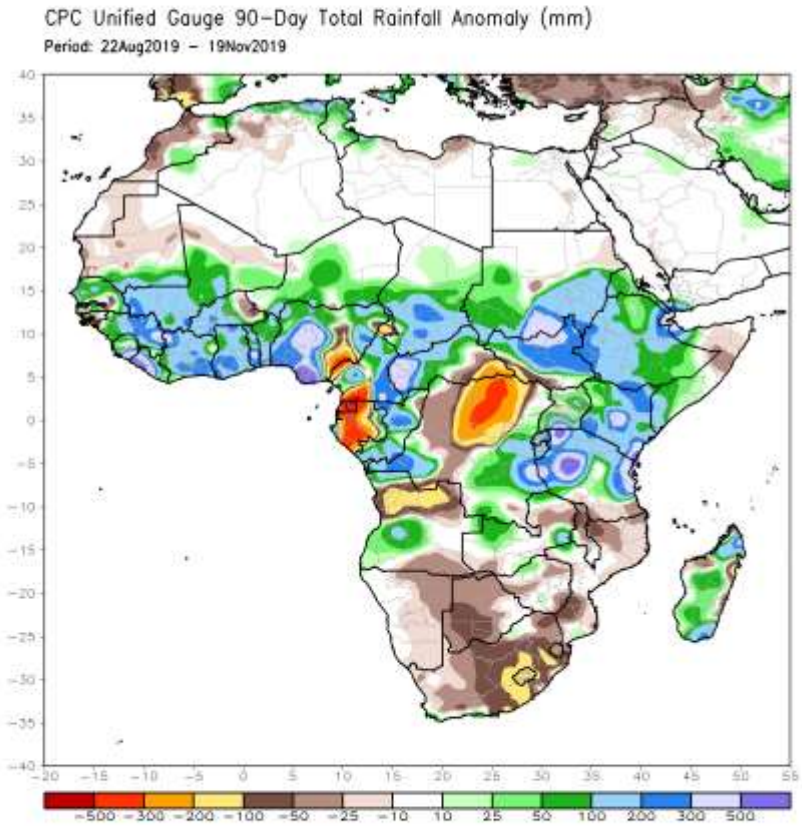
Observed Precipitation



90-day total



climatology

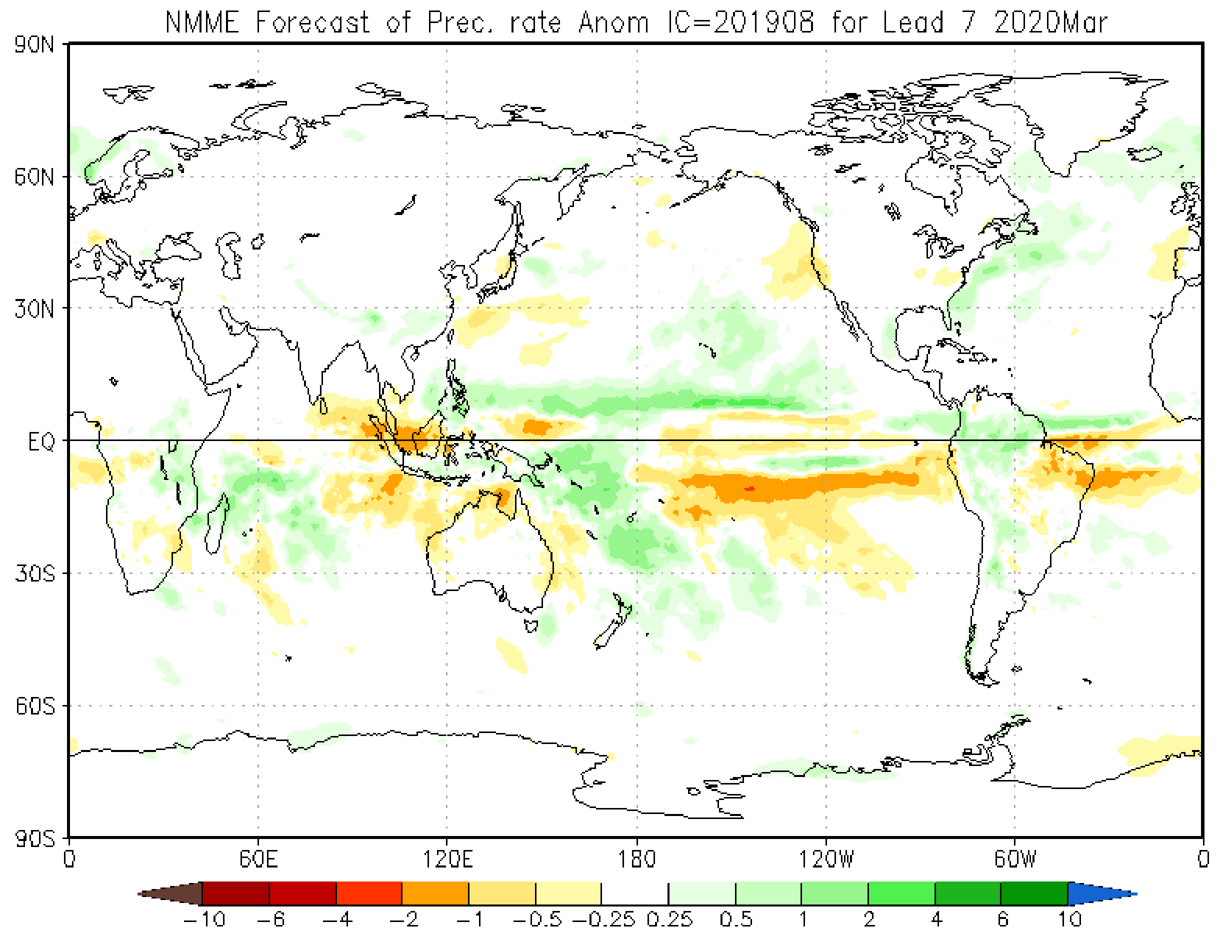


Anomaly

Fig. 12: 90-day precipitation total

https://www.cpc.ncep.noaa.gov/products/international/africa/africa.shtml

Precipitation Forecast



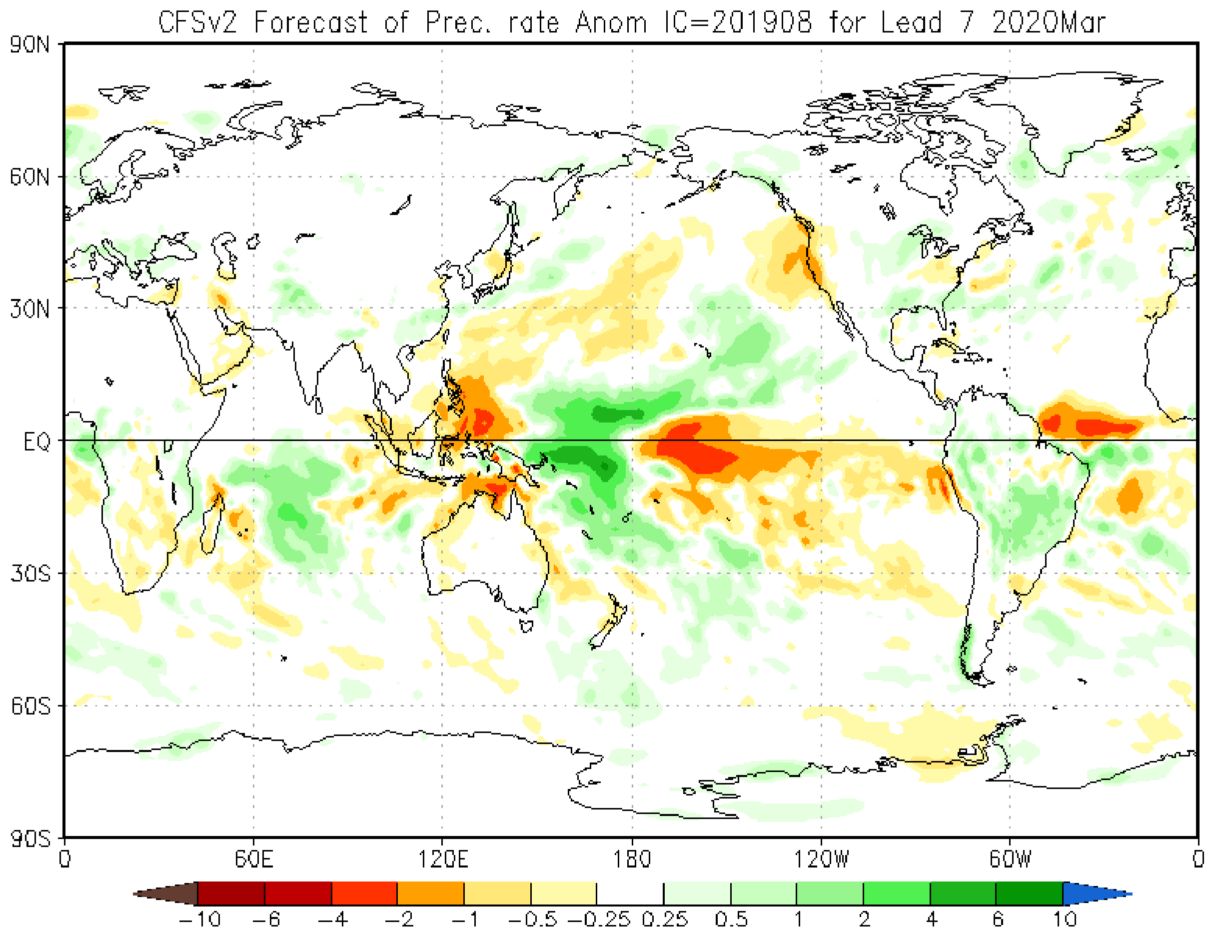


Fig. 13: Precipitation forecast with lead 7

https://www.cpc.ncep.noaa.gov/products/NMME/monanom.shtml

Conference / publication

1. **Haider M.R.**, Peña M., Nikolopoulos E., Dokou Z., and Anagnostou E.N. (2018). Bias Correction of Precipitation and Temperature Forecasts for Blue Nile Water Resources Management*. AGU Fall Meeting*. December 10-14, 2018. Washington, D.C., USA.

2. **Haider M.R.**, Peña M., Lazin R., Khadim F.K., Yang M., Dokou Z., Nikolopoulos E., and Anagnostou E.N. (2019). Enabling Numerical Seasonal Forecasts for High Resolution Modeling of Blue Nile River Basin. *44th Annual Climate Diagnostics and Prediction Workshop.* October 22–24, 2019. Durham, North Carolina, USA.

3. *Post-processing of Dynamical Model Output for Hydrologic Modeling of Blue Nile River Basin (In preparation).*

Thank you

NSF – PIRE: Water & Food Security Project

Survey Data Analysis Progress Report

Berihun Tefera Adugna, R.A, UCONN
Boris Bravo-Ureta, Professor, UCONN

Presented at Water & Food Security
NSF - PIRE Annual Meeting
November 21-22, 2019

UCONN

OUTLINE

1. INTRODUCTION: NSF-PIRE SURVEY
2. BASIC STATISTICS
3. PRODUCTION DATA
4. THE WAY FORWARD

1 – INTRODUCTION : NSF-PIRE Survey

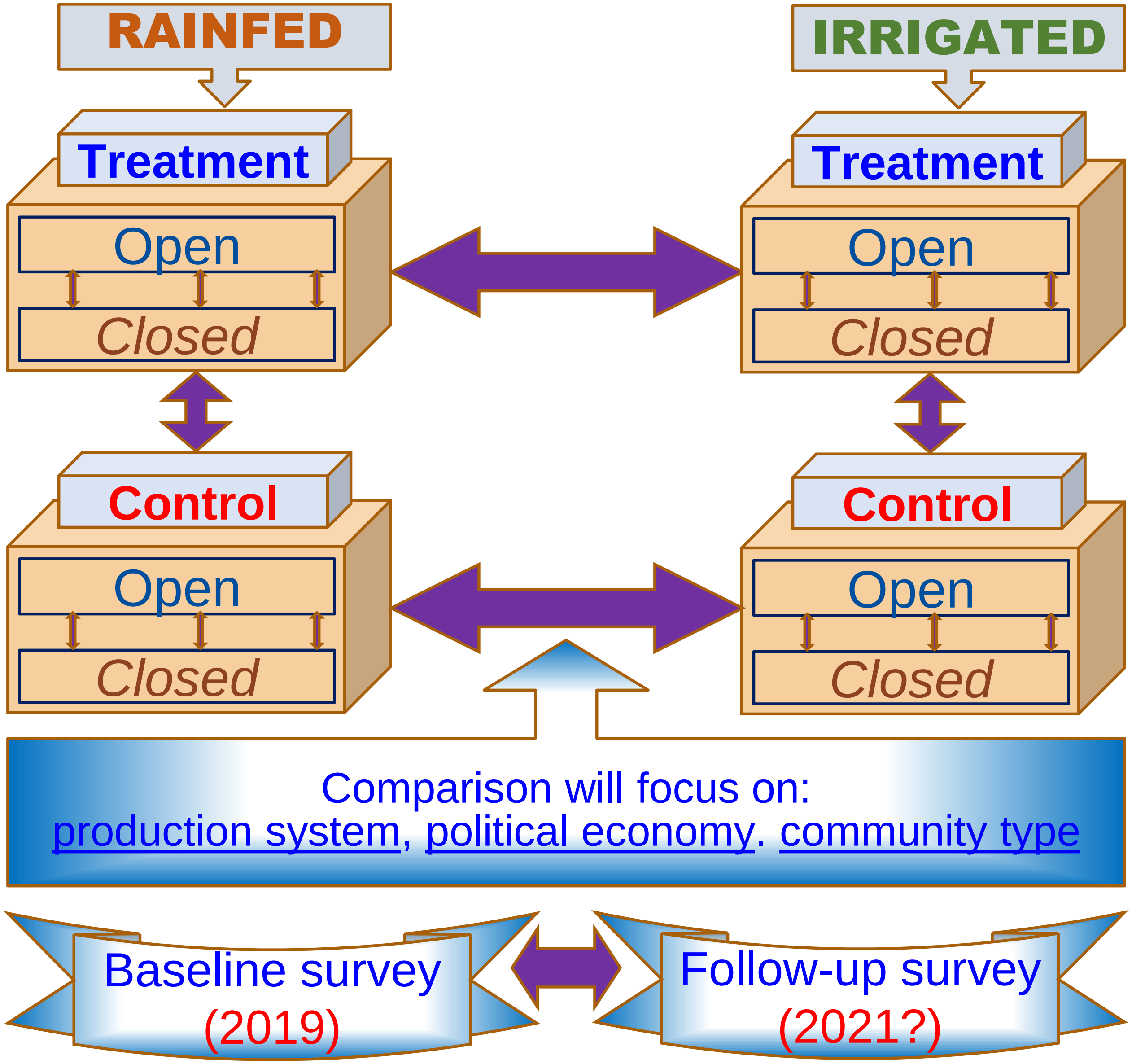
➢ Survey administration:

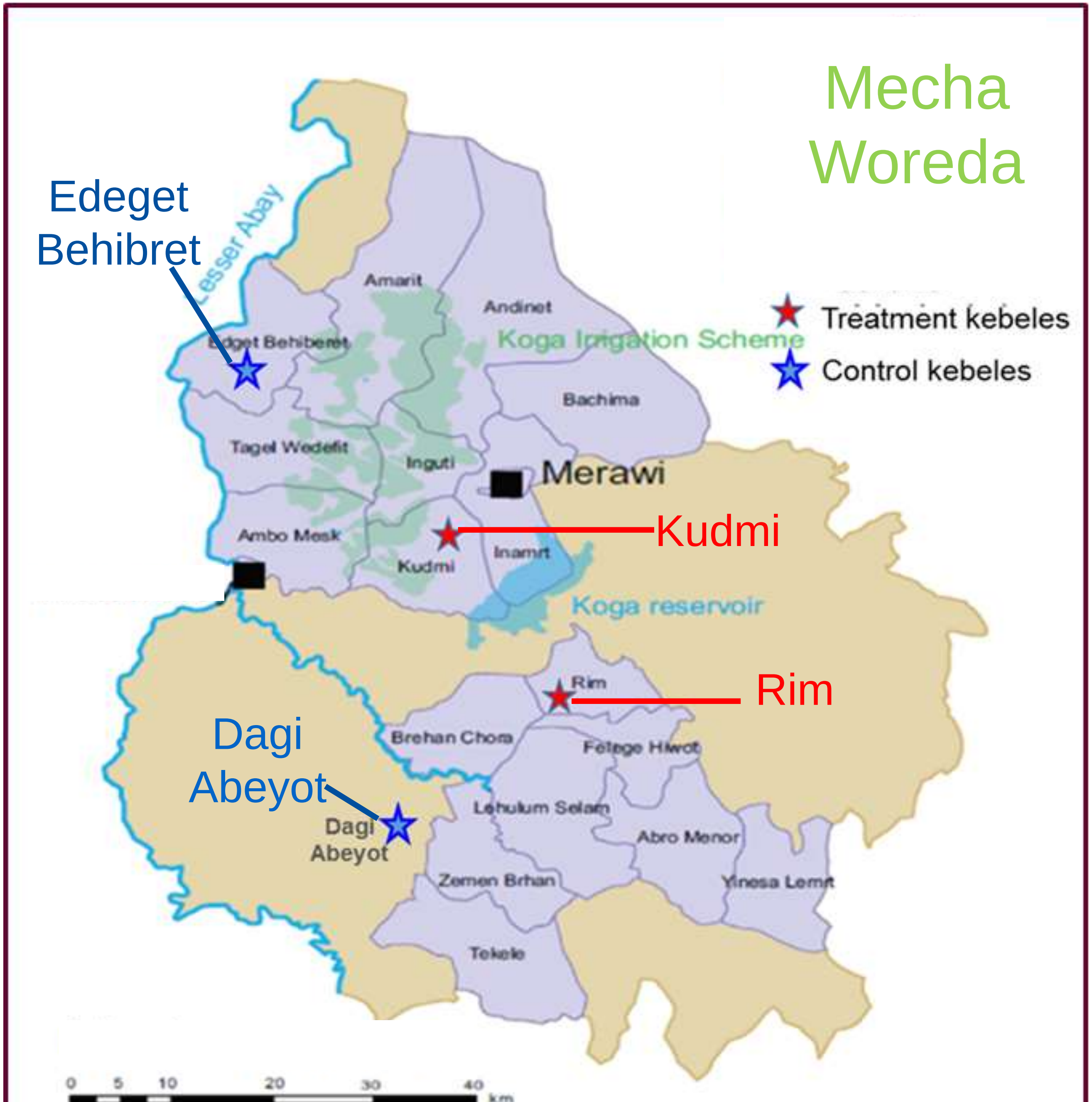
- Data collection instrument designed by an interdisciplinary group
- The questionnaire has 5 sections and 10 sub-sections
    1. General information and household profile
    2. Weather forecast
    3. Community participation and decision making
    4. Land, agricultural production, post-harvest management and non-farm activities
    5. Wealth indicators
- Data format: STATA, SPSS and Tab separated
- Survey administered using tablets and “Survey Solutions” (WB, 2017) - Computer-Assisted Personal Interviewing (CAPI).

Survey administration (2019)

- **Training :** March 14 - 22
- **Final questionnaire pretest:** March 23
- **Data collection:** March 24 - July 7
- **Data approval completed:** August 8
- **Data export:** September 2
- **Data filtration & cleaning:** September 12

Survey design





Mecha
Woreda
Edeget
Behibret
Lesser Abay
Amarit
Andinet
Koga Irrigation Scheme
Treatment kebeles
Control kebeles
Bachima
Tagel Wedefit
Inguti
Merawi
Kudmi
Ambo Mesk
Inamrt
Koga reservoir
Rim
Dagi
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Felege Hiwot
Lehulum Selam
Abro Menor
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Yinesa Lemrt
Tekele
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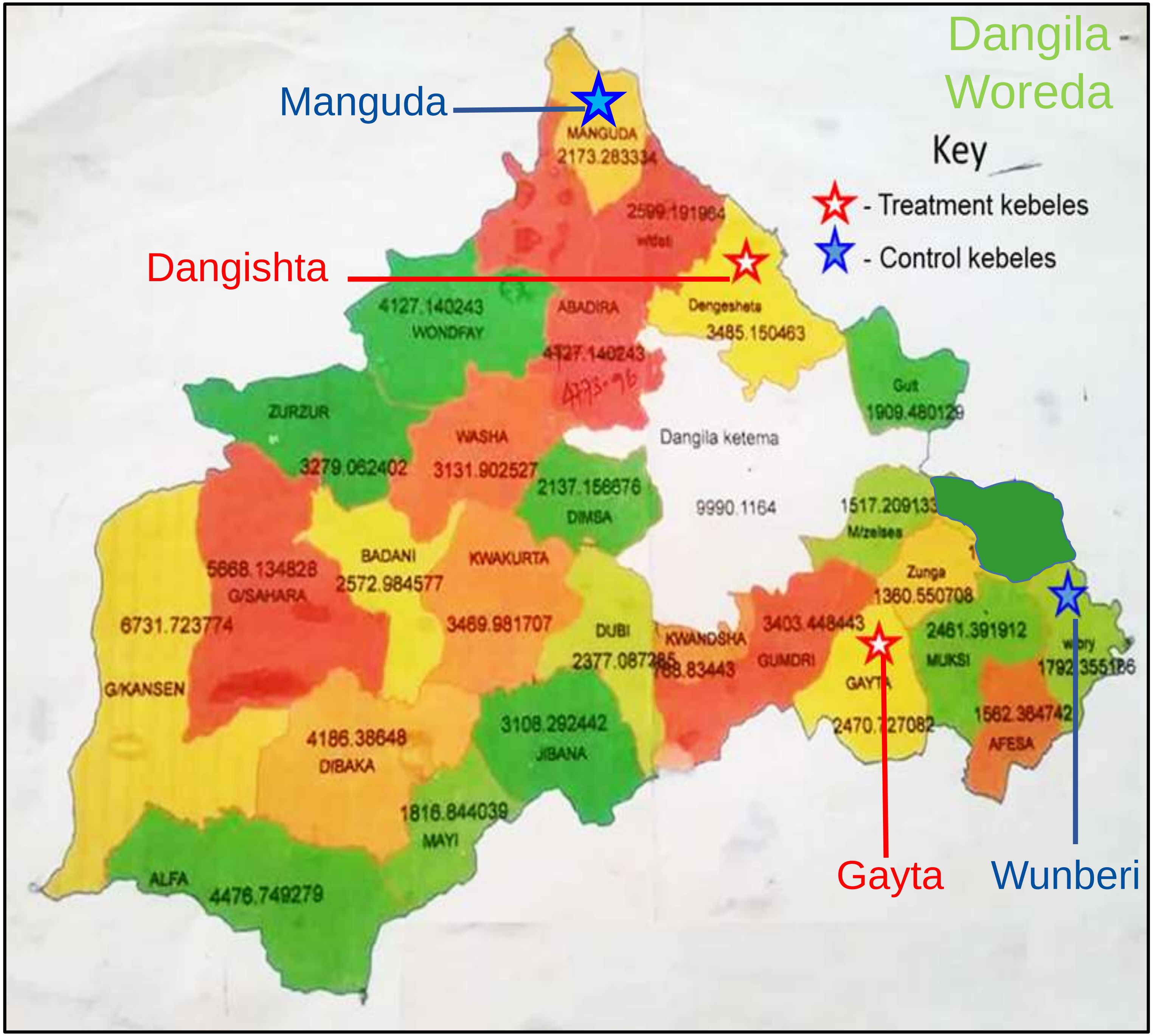
Dangila Woreda
Key
- Treatment kebeles
- Control kebeles
Manguda
Dangishta
Gayta
Wunberi
MANGUDA
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2599.191964
ABADIRA
Dengesheta
3485.150463
4127.140243
WONDFAY
ZURZUR
Gut
1909.480129
WASHA
Dangila ketema
3279.062402
3131.902527
2137.158676
DIMSA
9990.1164
M/zelsea
BADANI
KWAKURTA
5668.134828
G/SAHARA
2572.984577
Zunga
1360.550708
6731.723774
3469.981707
DUBI
KWANDSHA
3403.448443
2461.391912
MUKSI
GUMDRI
GAYTA
G/KANSEN
3108.292442
JIBANA
2470.727082
1562.384742
AFESA
4186.38648
DIBAKA
1816.844039
MAYI
ALFA
4476.749279

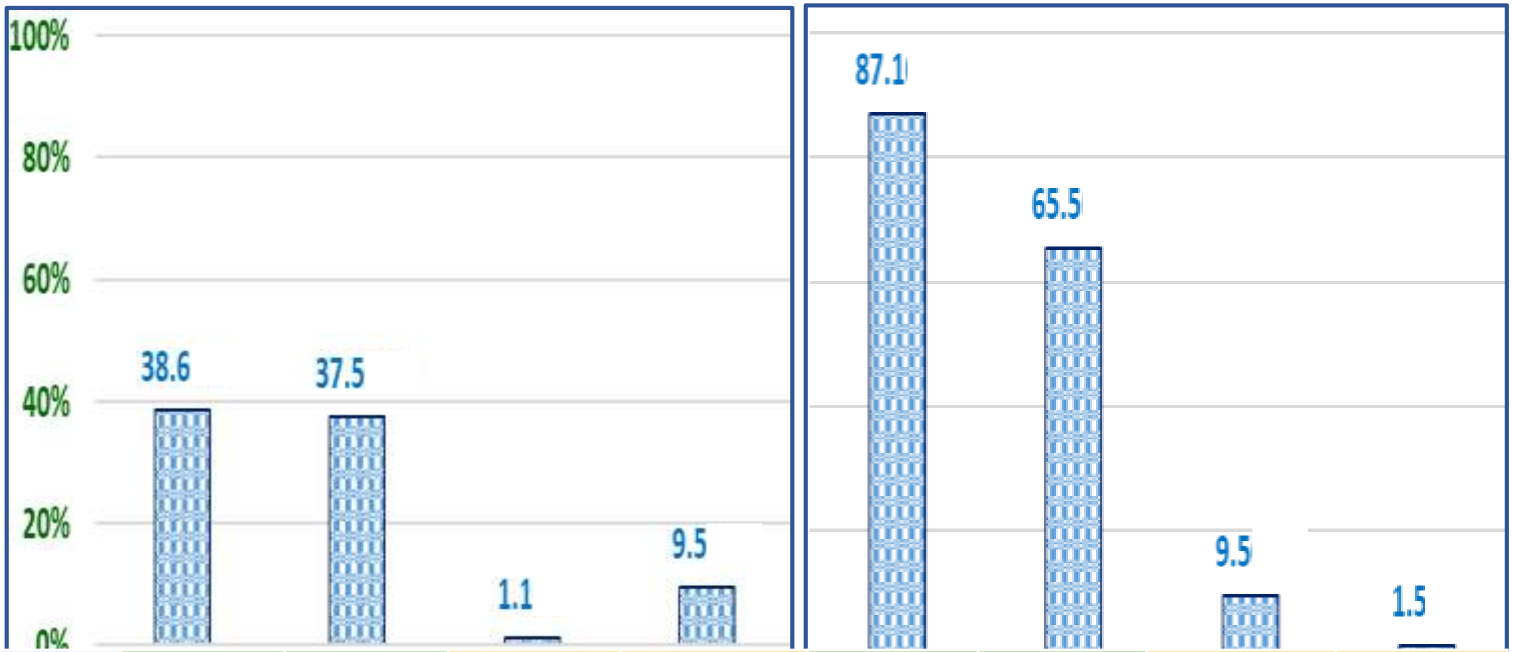
Data cleaning

- Total responses: 1865 HHs
- 9 HHs dropped = 1856 HHs
- 80 independent STATA files - merged, appended and cleaned to generate 3 data sets (Aggregate, Production & Household demographics)
- Unique and group identifiers included in each data set.

Sample description

Treatment: 4 kebeles - 928 HHs   Control: 4 kebeles - 928 HHs

HHs with Irrigation (% total sample)



	Gayta	Kudmi	Rim	Dangisht	Wunbri	Edeget	Dagiabe	Mangud
- Pairing	T1	T2	T3	T4	C1	C2	C3	C4
- Kebele (T=8)	1	1	1	1	1	1	1	1
- Villages(T=84)	11	10	11	10	11	10	11	10
- HHs (T=1856)	264	200	264	200	264	200	264	200
- Community	Open	Closed	Open	Closed	Open	Closed	Open	Closed
- Irrigation	Irrig	Irrig	Rainfed	Rainfed	Irrig	Irrig	Rainfed	Rainfed

2 – BASIC STATISTICS

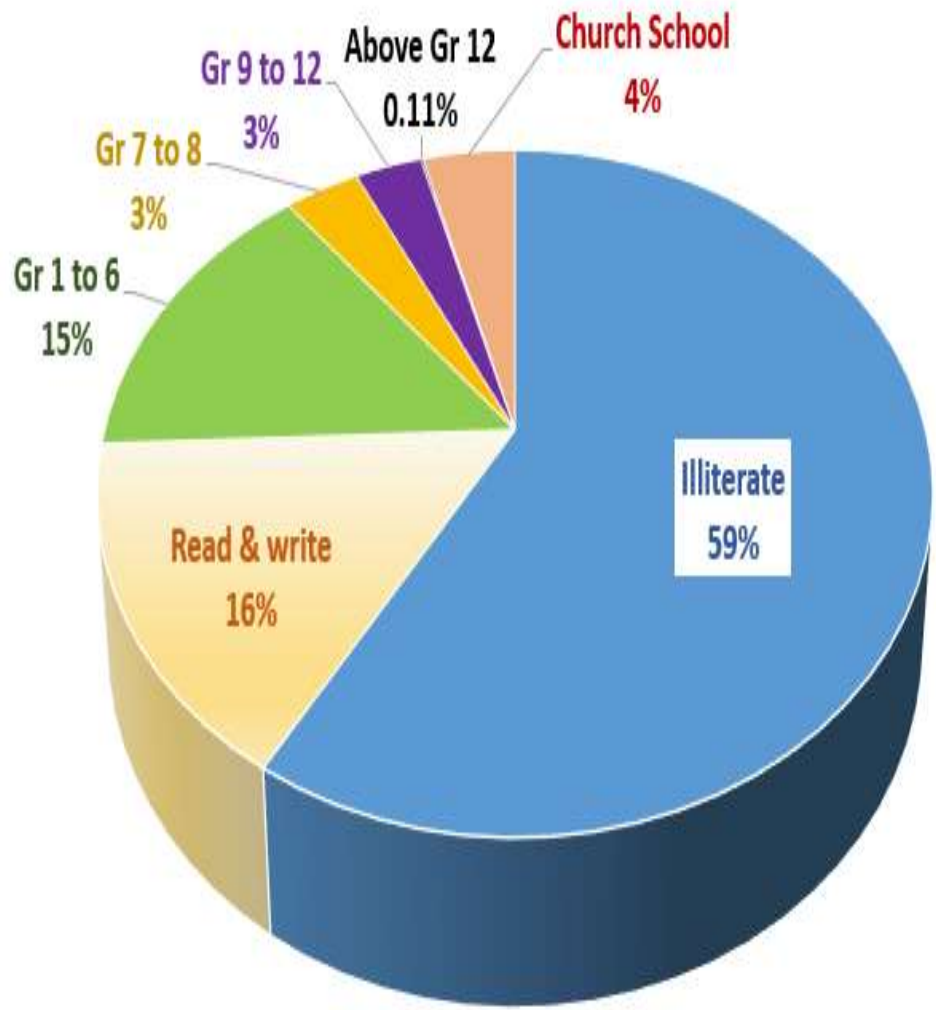
Household characteristics

- Average age of HH head = 46.8 years *(SD 13.3 years)*;
  - Treatment - 45.9 years & Control 47.8 years
- Average family size = 5.5 persons *(SD = 1.95 persons) for both treatment & control*
- *Share HHs reporting food shortage (> 2 weeks, last year)*
  - Treatment group = 5.7%; Control group = 5.2%
  - Woredas: N/Mecha = 1.6%; Dangila = 8.8%

➢Household head characteristics: N =1856

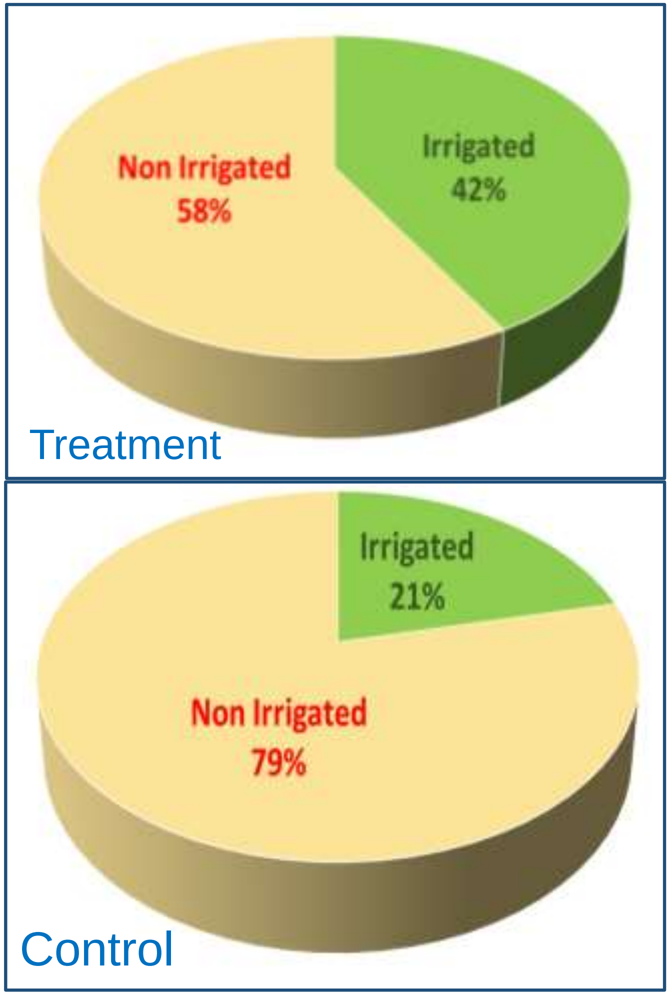
Sex

Marital status

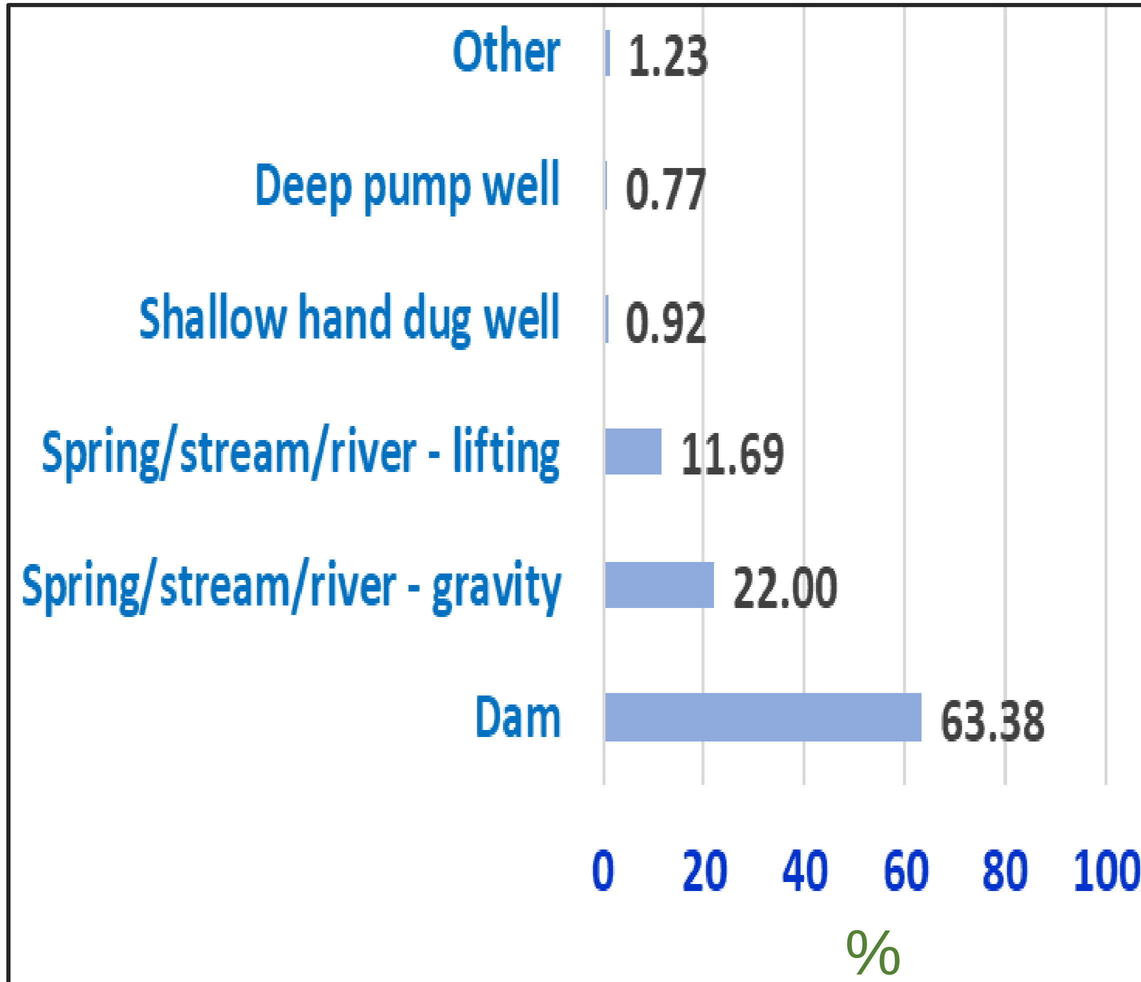


Education level

➢Irrigation practices

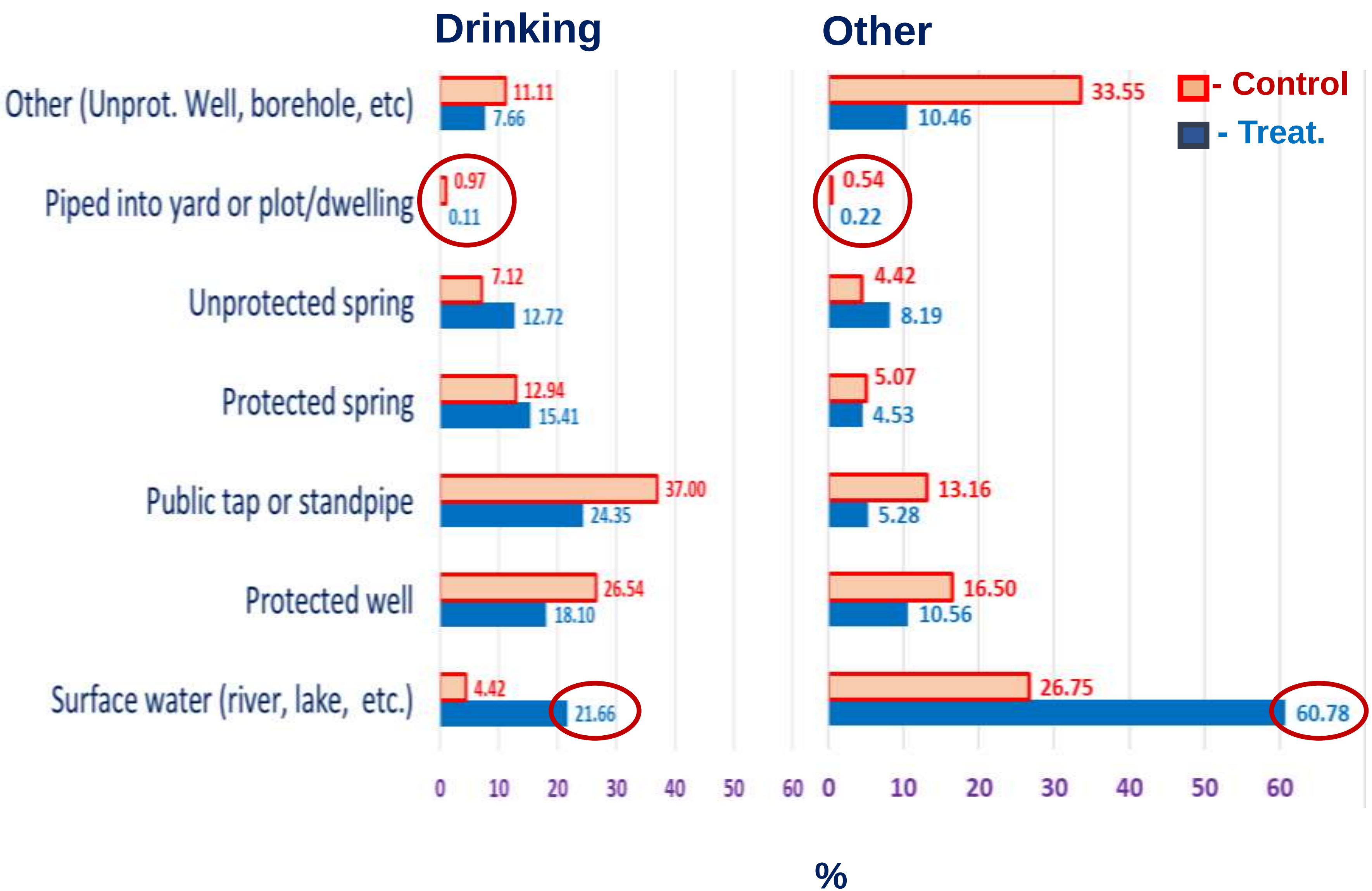


Irrigation practice
(N = 1856 HHs/Total)



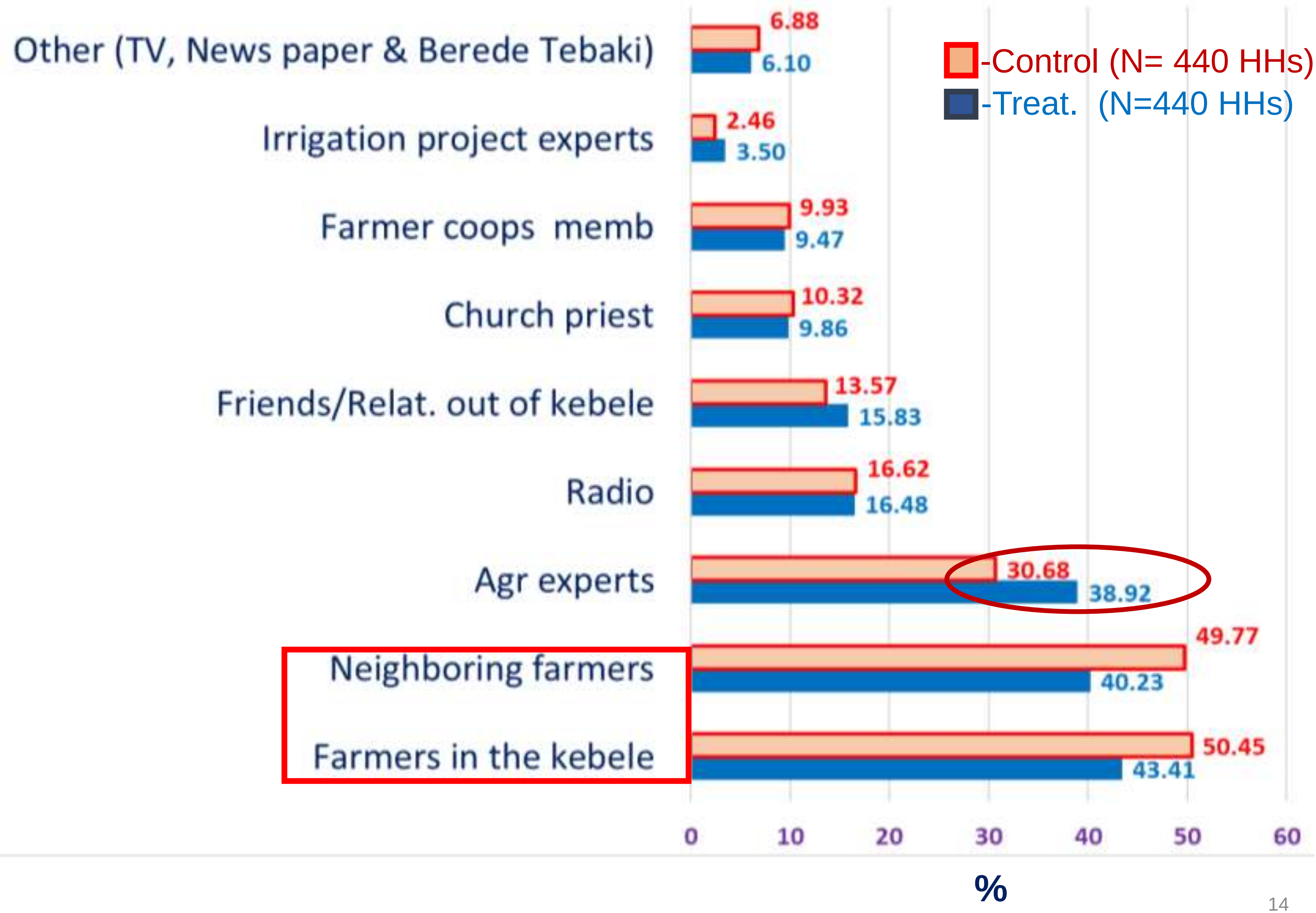
Sources of irrigation water
(N=583 HHs/Irrigation users)

➢Water sources (N=1856 HHs)

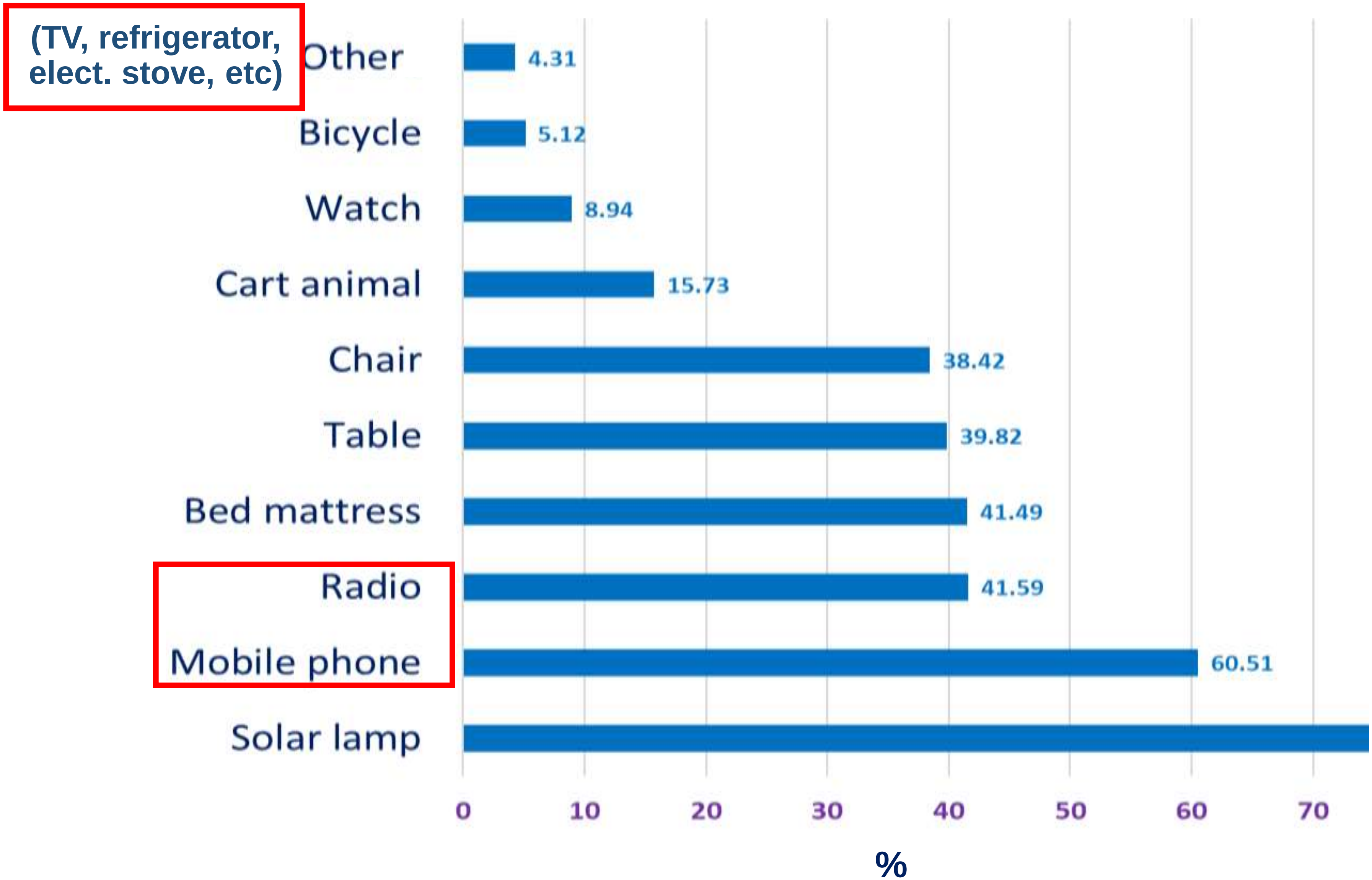


➢Sources of hydro climatic forecast information:

Share in % (Total N = 880 HHs) – Multiple answers

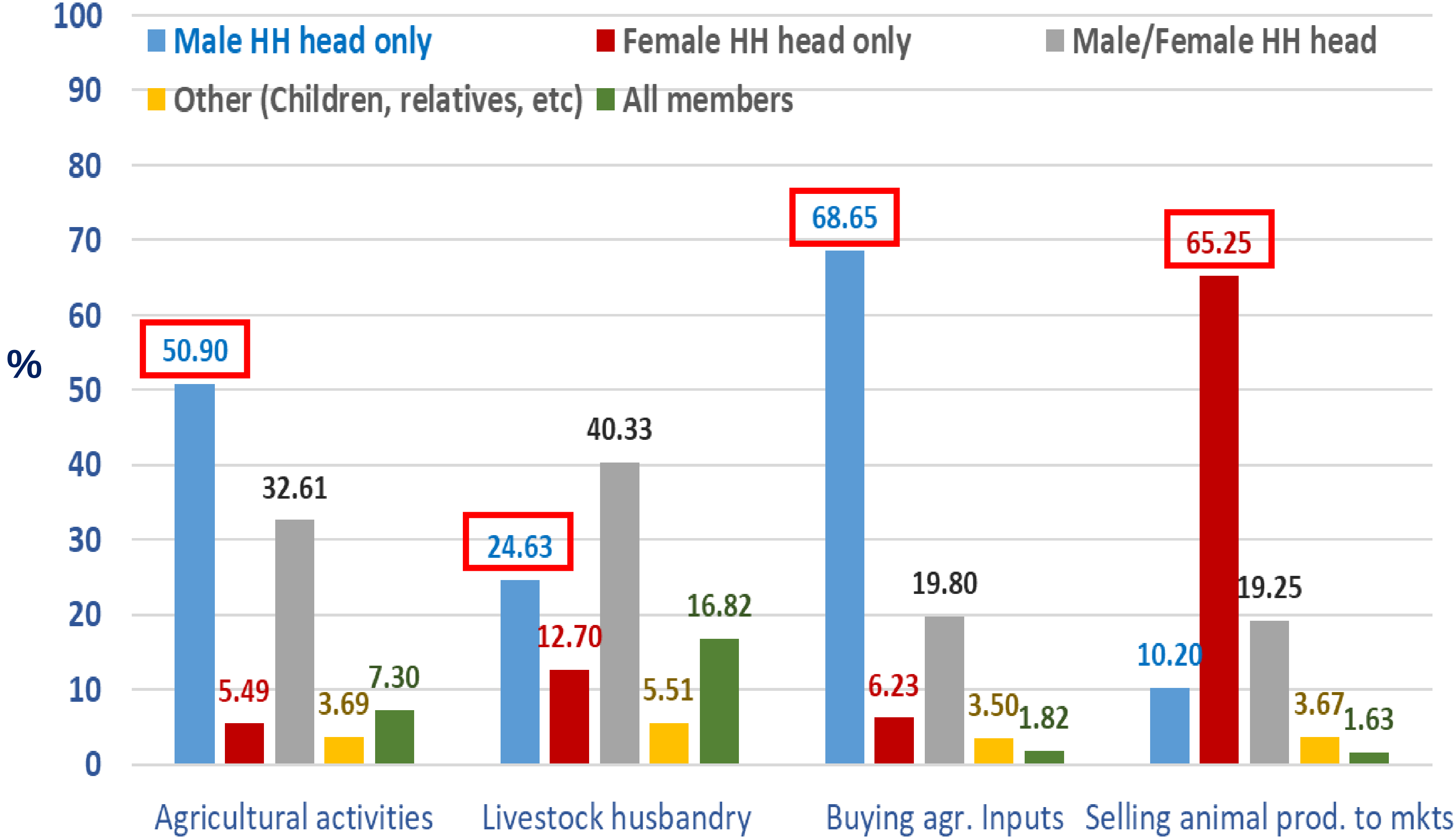


➢Asset ownership (N=1856 HHs)

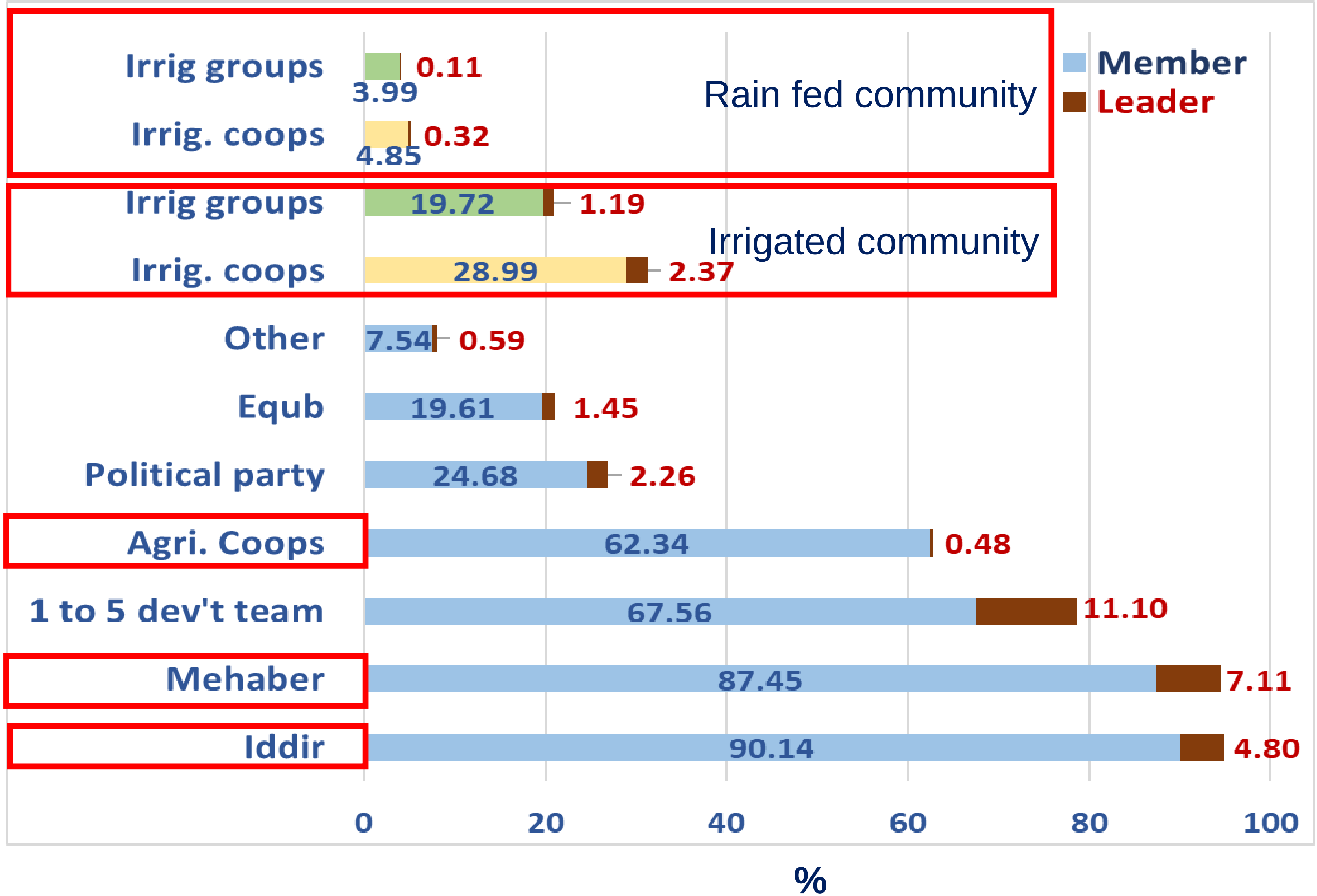


➢ HH members participation in different activities (%)

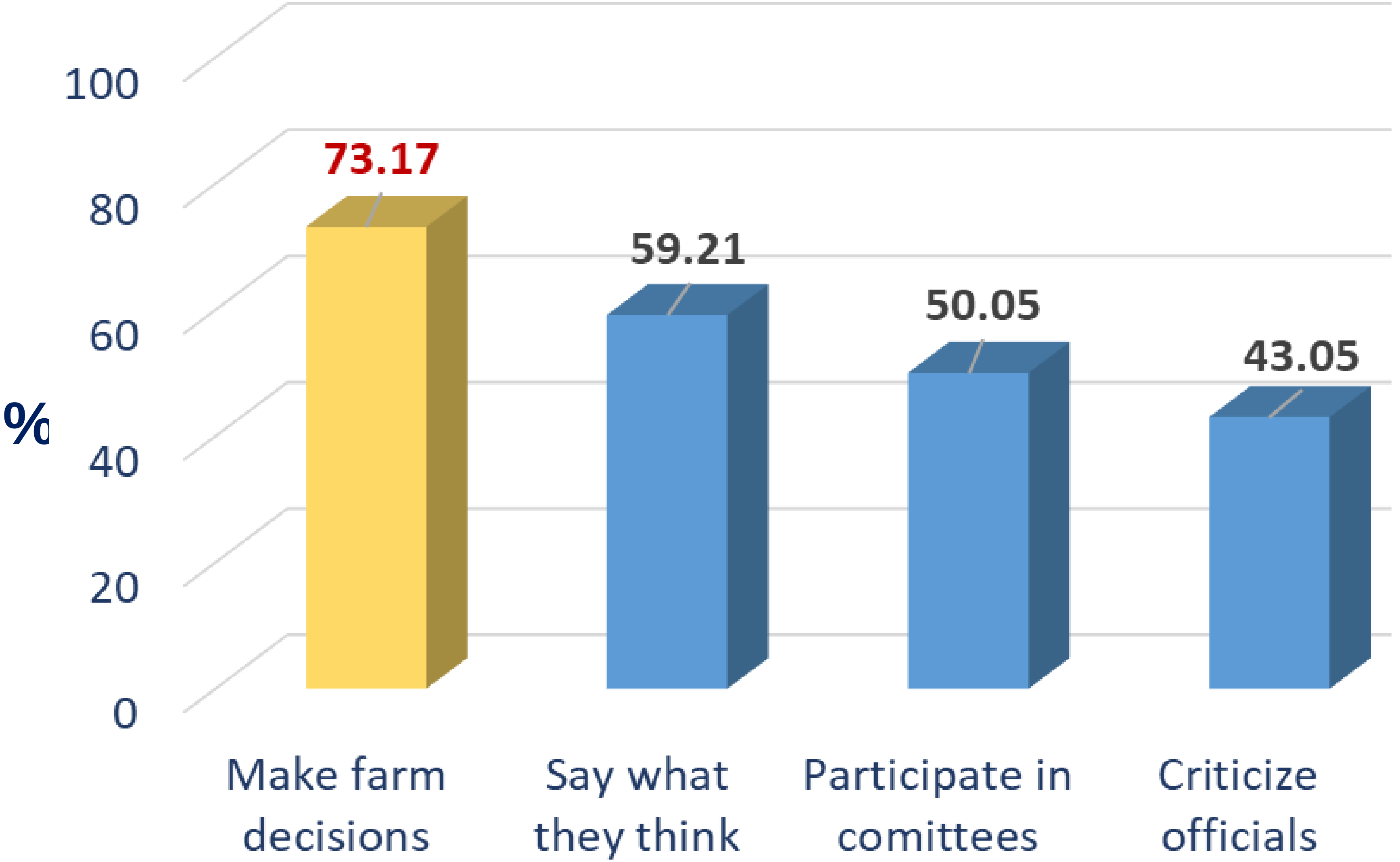
- N = 1730 HHs
- Gender difference in activities: Yes=1472 (85.1%); No=258 (14.9%)



➢ Membership & leadership role of HH heads in local institutions (%) (N=1856 HHs)



➢Percentage of HHs (N=1856 HHs) completely free to:



3 - PRODUCTION DATA

➢ Unit of Analysis

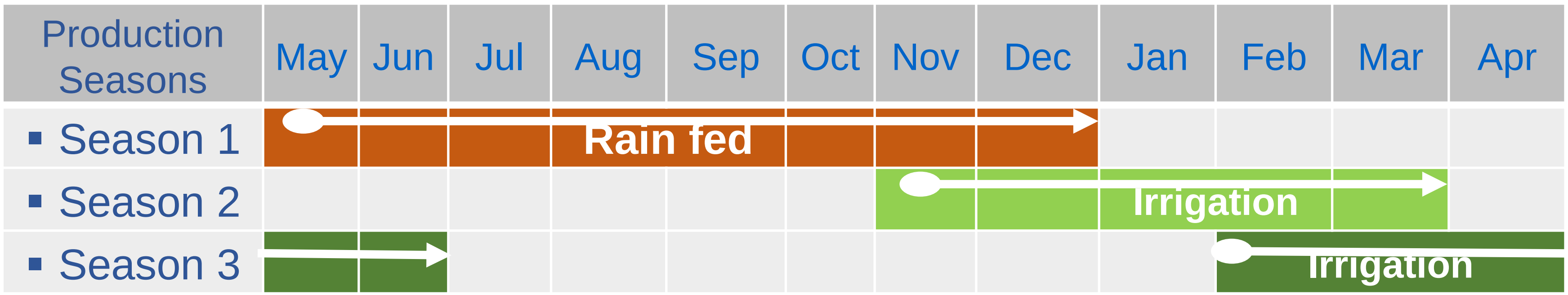
- The key unit in this production data analysis is a **plot**
- **A plot** is the specific area of land used by the household for a purpose in a season (e.g. a maize plot in Meher season of production)
- Our survey collects data about all of a household’s plots including land rented or shared as well as owned in 2018
- A plot is not a measure of the quantity of land. Key terms used to describe the **quantity** of land are **hectare** and **qada**. Four qadas = 1 hectare

➢Plot selection for production analysis

Plot/HH description	No	%
➢ **Plots**		
▪ Total	9,866	100.0
– Not cultivated (fallow, const.., etc)	1,209	12.3
– Cultivated (Crop, tree and grass)	*8,657*	87.7
• *Crop*	*6,973*	70.7
• Eucalyptus and *Acacia dicurence*	*1,251*	12.7
• Grass	*433*	4.4
▪ Single stand crop (all crops)	6,671	67.6
▪ Single stand major crops (Maize, Finger Millet & Teff): 68.1% of single stand crop plots	4,545	46.1
▪ Plot size range in Ha	0.01-2.75	
➢ **HHs –** cultivating 3 major crops (95.1% of 1856 HHs)	1,765	

➢There are two production systems & three seasons

Production seasons

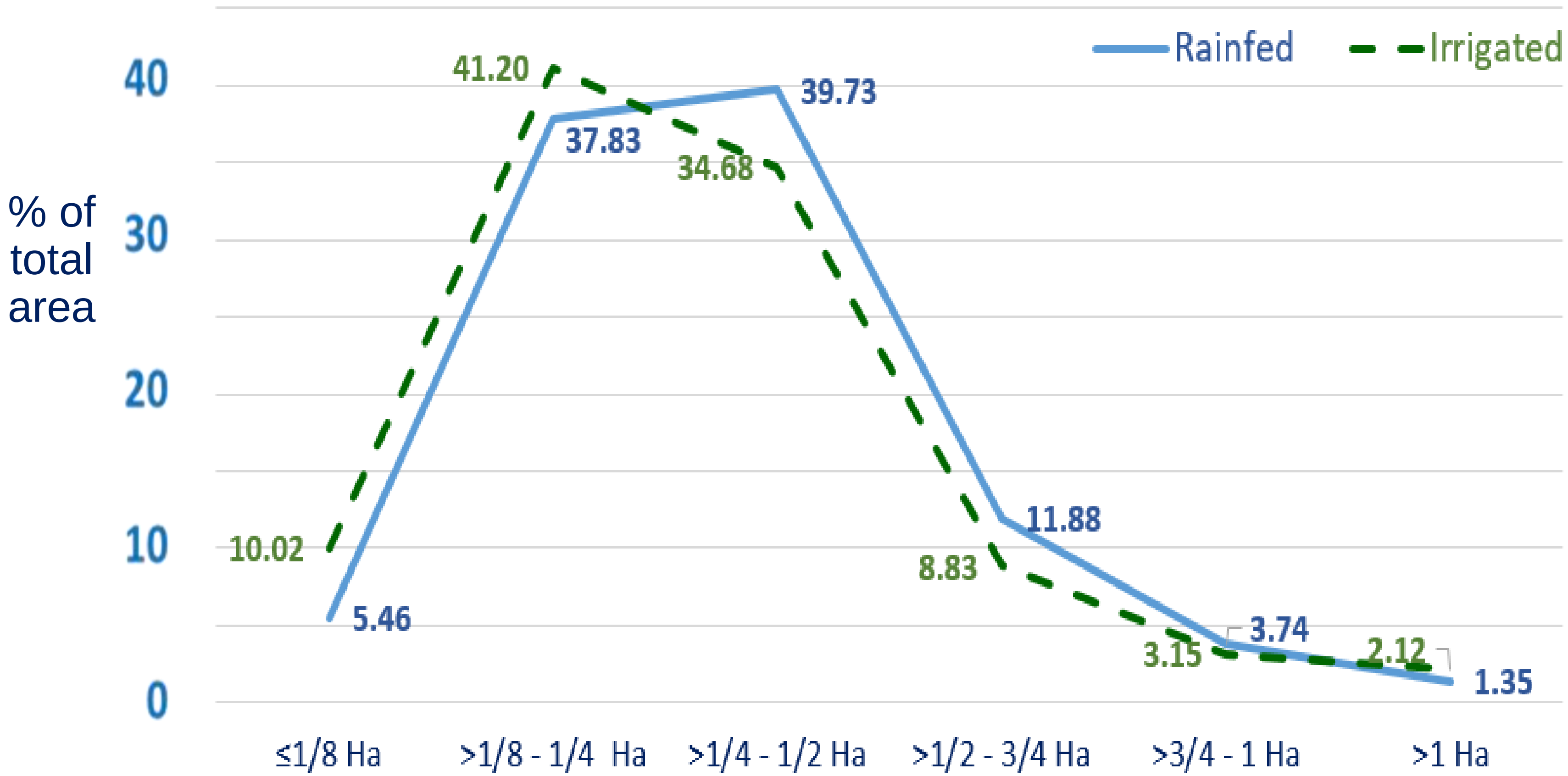


➢Frequency of cultivation on each plot by season and community type

Production season	Rain fed community		Irrigated community		Total	
	No.	%	No.	%	No.	%
S1 only	3,774	98.5	3,842	79.6	7,616	88.0
S2 only	20	0.5	130	2.7	150	1.7
S3 only	0	0	20	0.4	20	0.2
S1 & S2	32	0.8	586	12.1	618	7.1
S1 & S3	4	0.1	14	0.3	18	0.2
S2 & S3	2	0.1	182	3.8	184	2.1
S1, S2 & S3	0	0	51	1.1	51	0.6
Total	**3,832**	**100.0**	**4,825**	**100.0**	**8,657**	**100.0**

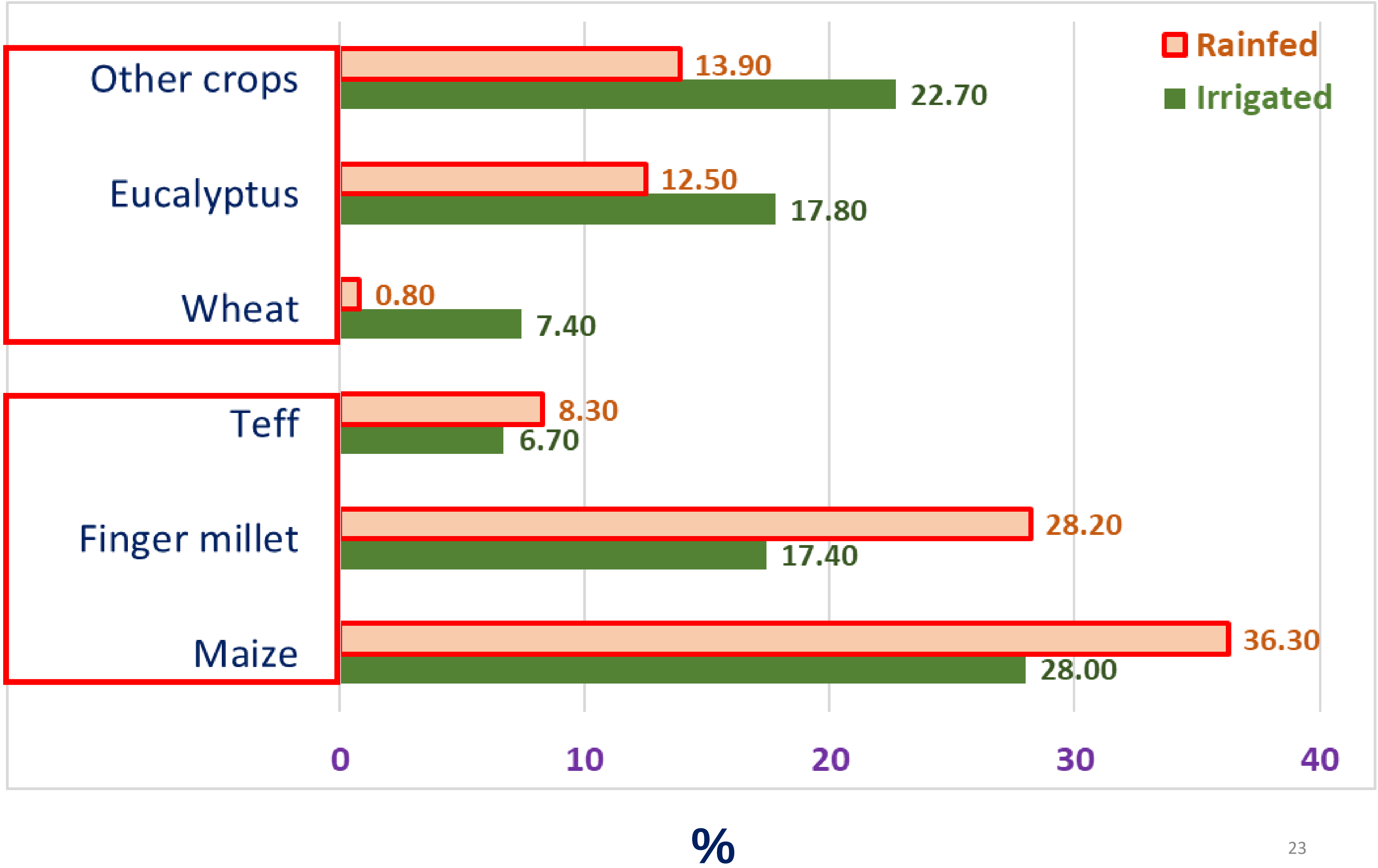
➢Number and size of cultivated plots (crop, tree & grass)

- **Mean No. plots/ HH: All = 4.7**
- **Mean Ha/Plot: All = 0.3 Rain fed = 0.32 Irrig. = 0.28**
- **Mean Ha/HH: All = 1.38 Rain fed = 1.31 Irrig. = 1.46**



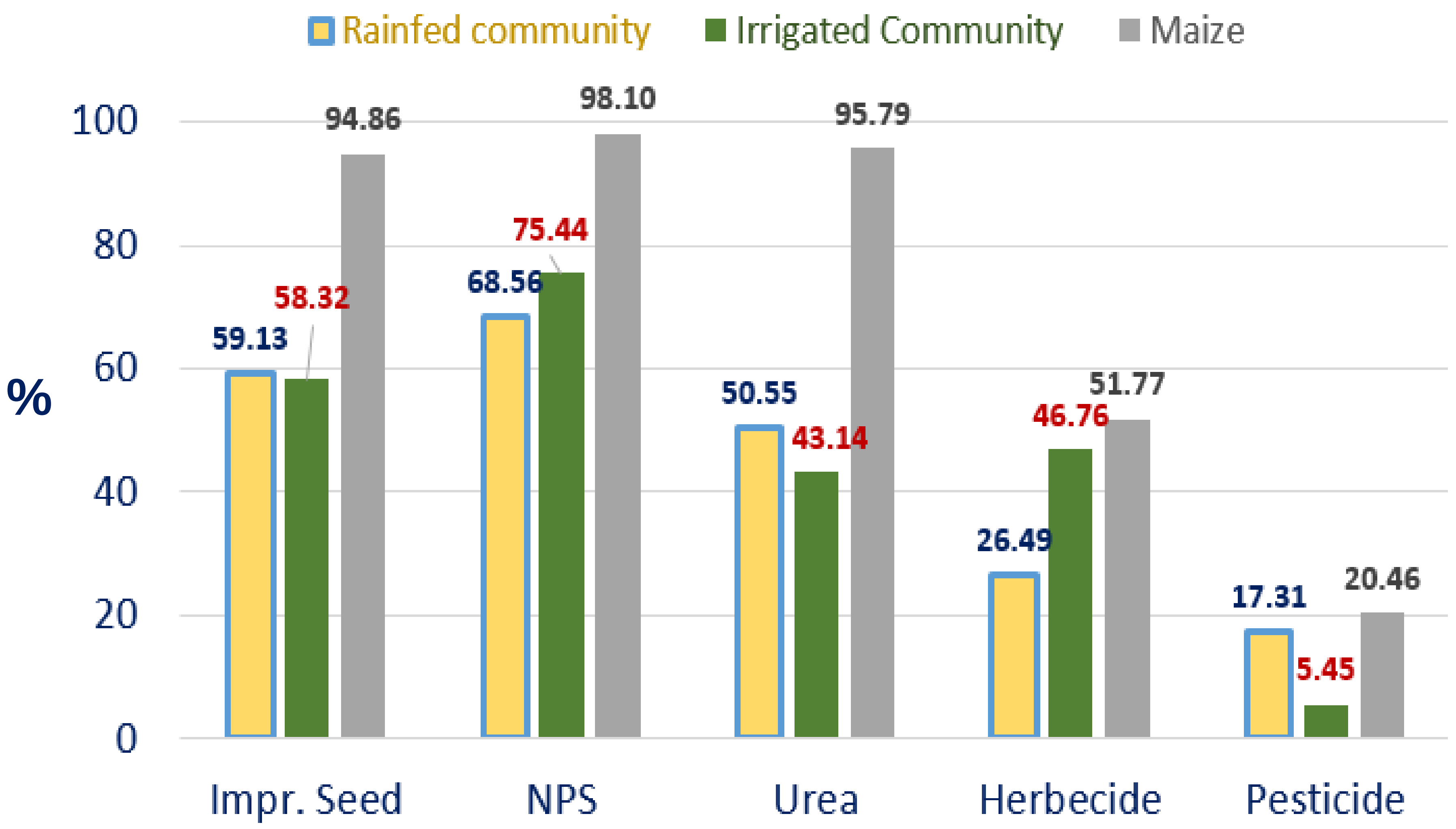
Area cultivated in 2018

- Total = 2,578.3 Ha; Rain fed Comm. = 1,219.5 Ha; Irrig. Comm. = 1,358.7 Ha



➢Improved agricultural input use in crop cultivation plots

- No. of plots: Rain fed comm. =2,853; Irrigated comm. = 2,235; Maize =2545



➢ Status of data cleaning and analysis

❑ Appended, merged and cleaned data – ready to transfer

- Two data files: Weather forecast and all other variables
- Production data set not completed
- Other variables include household profile, Community participation & decision making, Non-Farm Enterprise & Wealth indicators.
- Variable directory (Codebook with additional notes) for the two data sets – completed.

❑ Production data set for major crops (Maize, Finger millet and Teff)

- Maize grain – Completed, needs some local unit conversion rate determination
- Finger millet and Teff - started, but not completed

❑ Some analysis on other variables (completed but not presented)

4. THE WAY FORWARD

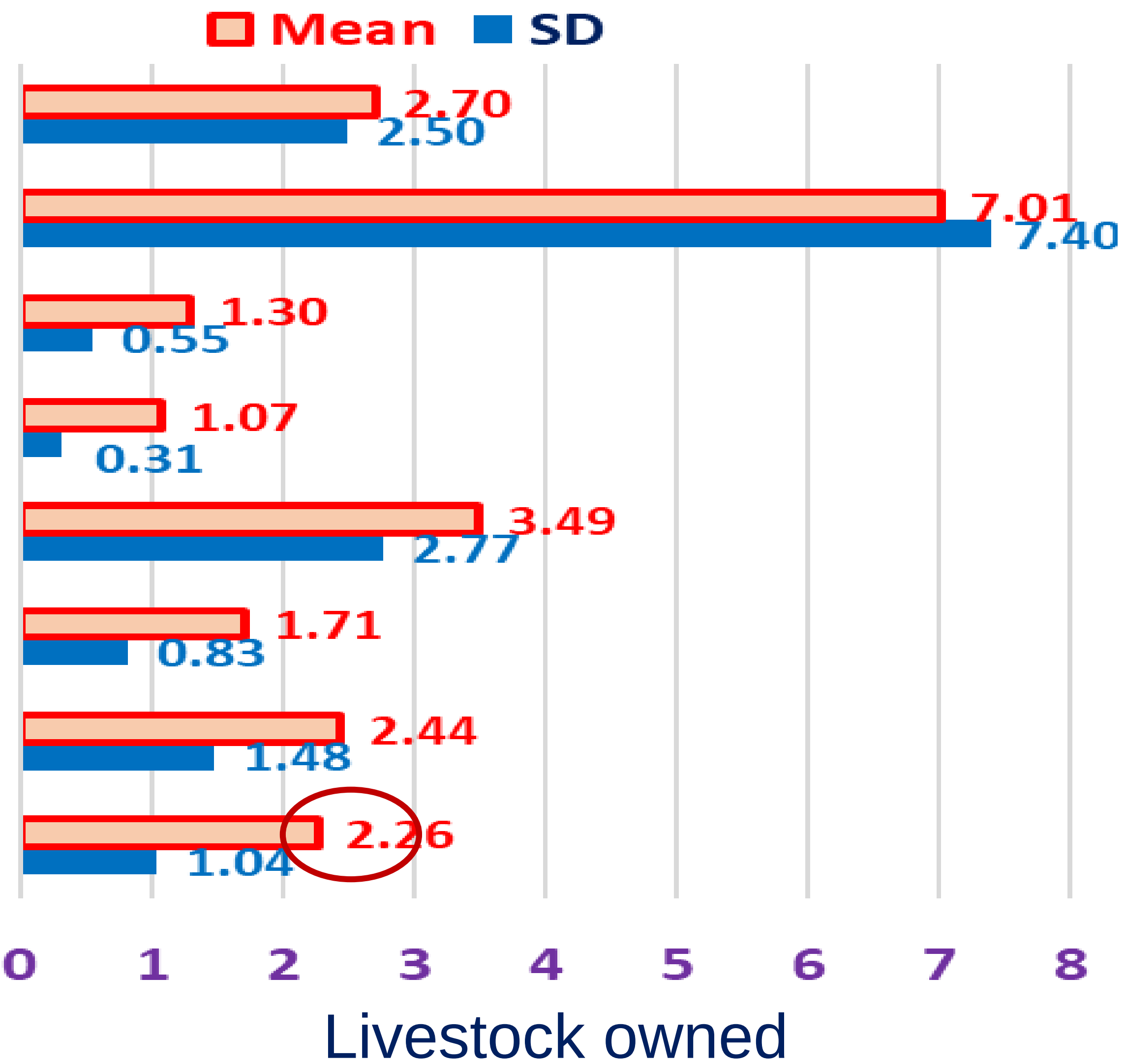
- Transfer of data sets
- Share variable directory (codebook with some additional notes) to PIRE students and research group.
- Clean & generate aggregate input & output variables
- Write papers on major/all crop/s production.

THANK YOU!

Additional slides

➢ Number of livestock units owned per HH

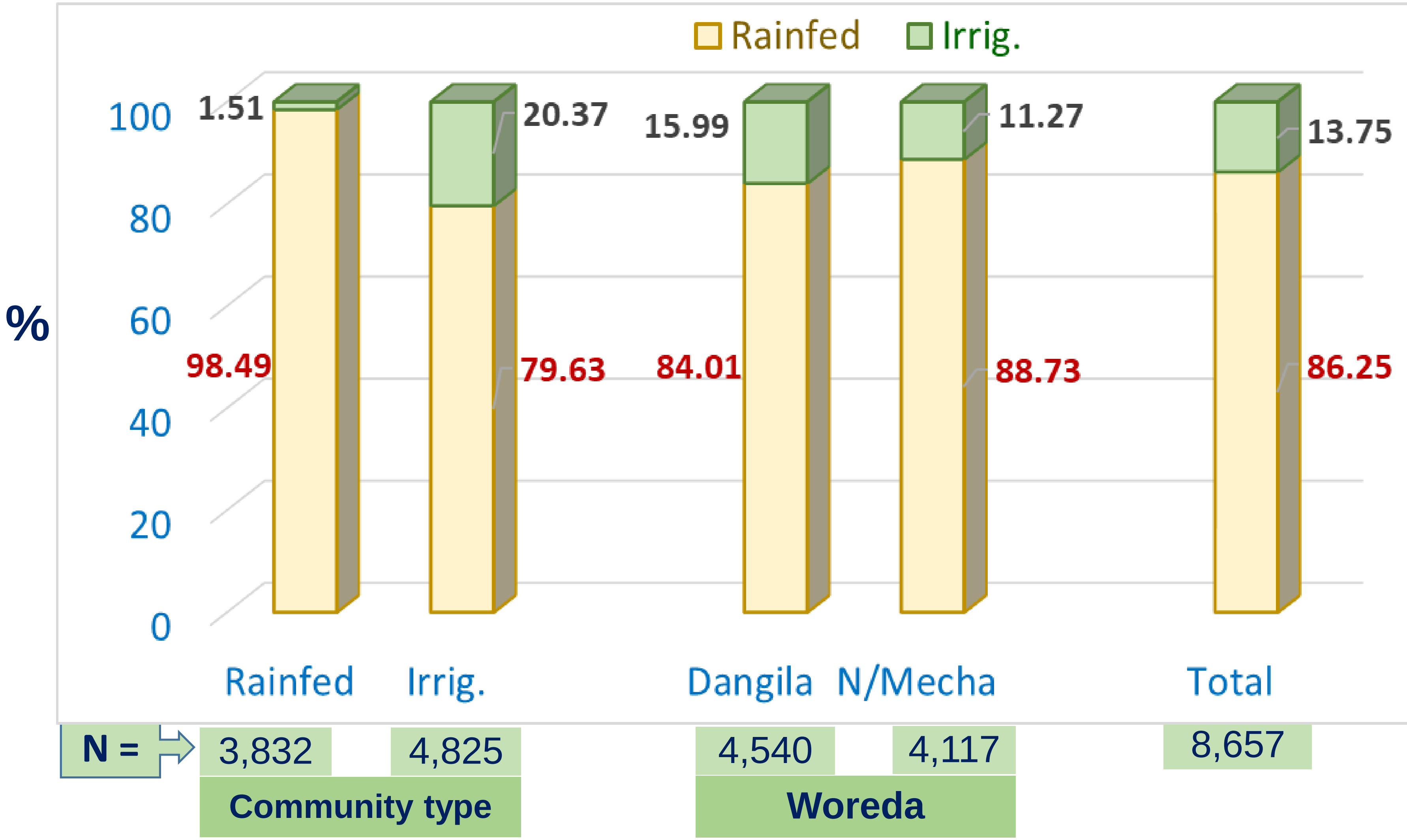
Livestock	N(HHs)	Max
Bee colony	204	25
Chicken	1,314	100
Donkey	662	4
Horse	378	4
Sheep/Goat	1,060	30
Calves	1,408	7
Cow/Heifer	1,638	23
Ox/Bull	1,537	8



No and size of plots cultivated in 2018

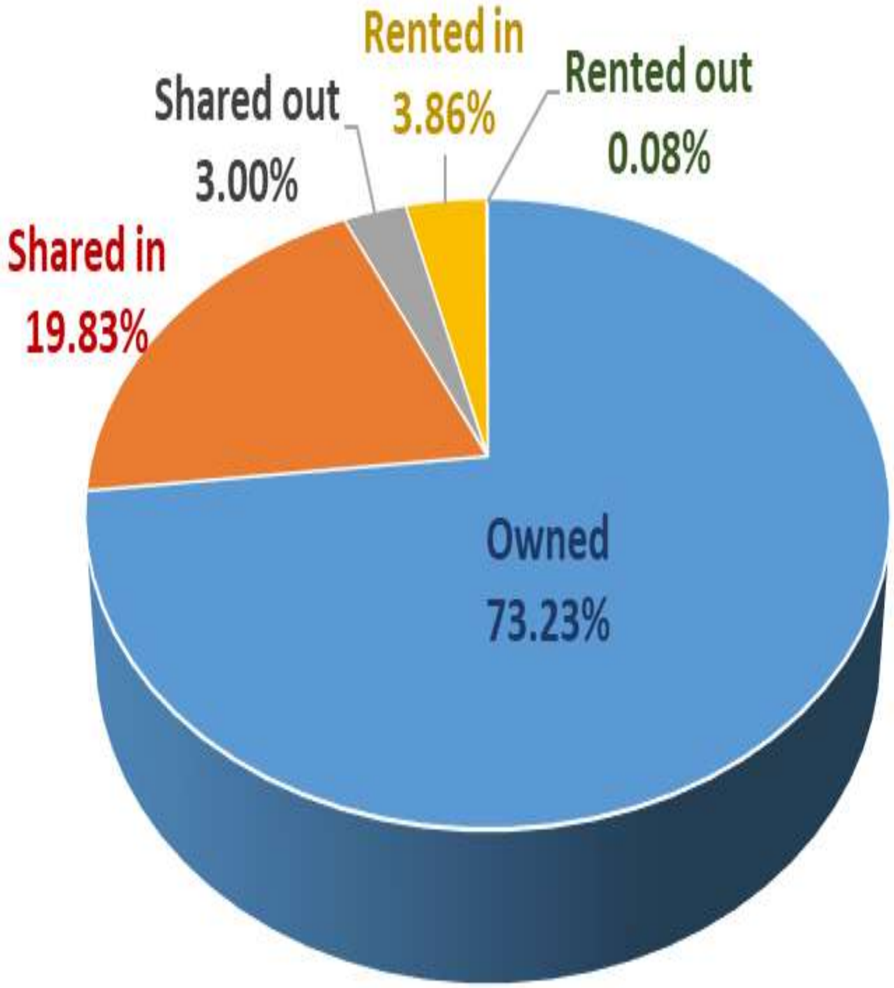
Crop cultivated	Irrigated community				Rainfed community			
	No of plots		Area		No of plots		Area	
	No	%	Ha	%	No.	%	Ha	%
Maize	**1,352**	**28**	**380.5**	**28**	**1,331**	**29.4**	**443.1**	**36.3**
Finger millet	720	14.9	236.5	17.4	946	20.9	343.9	28.2
Teff	282	5.8	91	6.7	318	7	101.3	8.3
Wheat	307	6.4	100.7	7.4	44	1	9.4	0.8
Eucalyptus	1,245	25.8	241.2	17.8	1,210	26.7	152.3	12.5
Other crops	919	19	308.7	22.7	685	15.1	169.5	13.9
Total	4,825	100	1,359	100	4,534	100	1,220	100

➤% of plots cultivated: rain fed & irrigated (N=8657 plots)

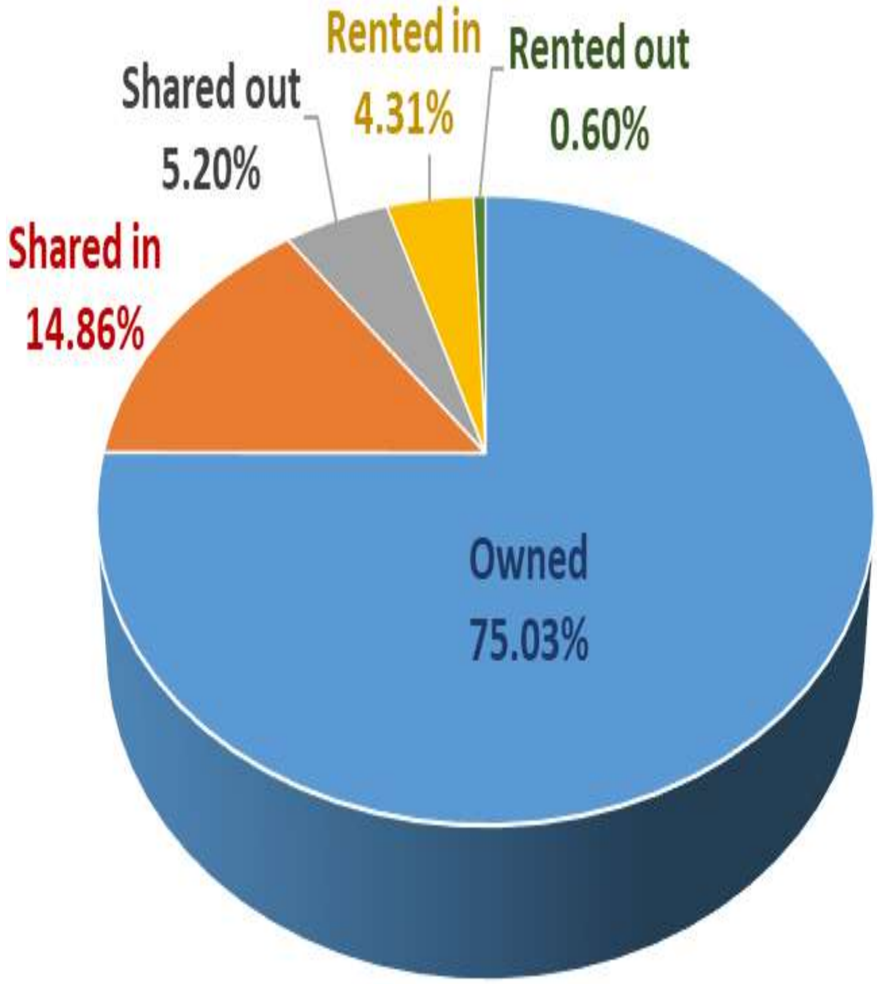


Plot ownership status

- **Plots: Total= 8657; Rain fed = 3832 ; Irrigated = 4825**



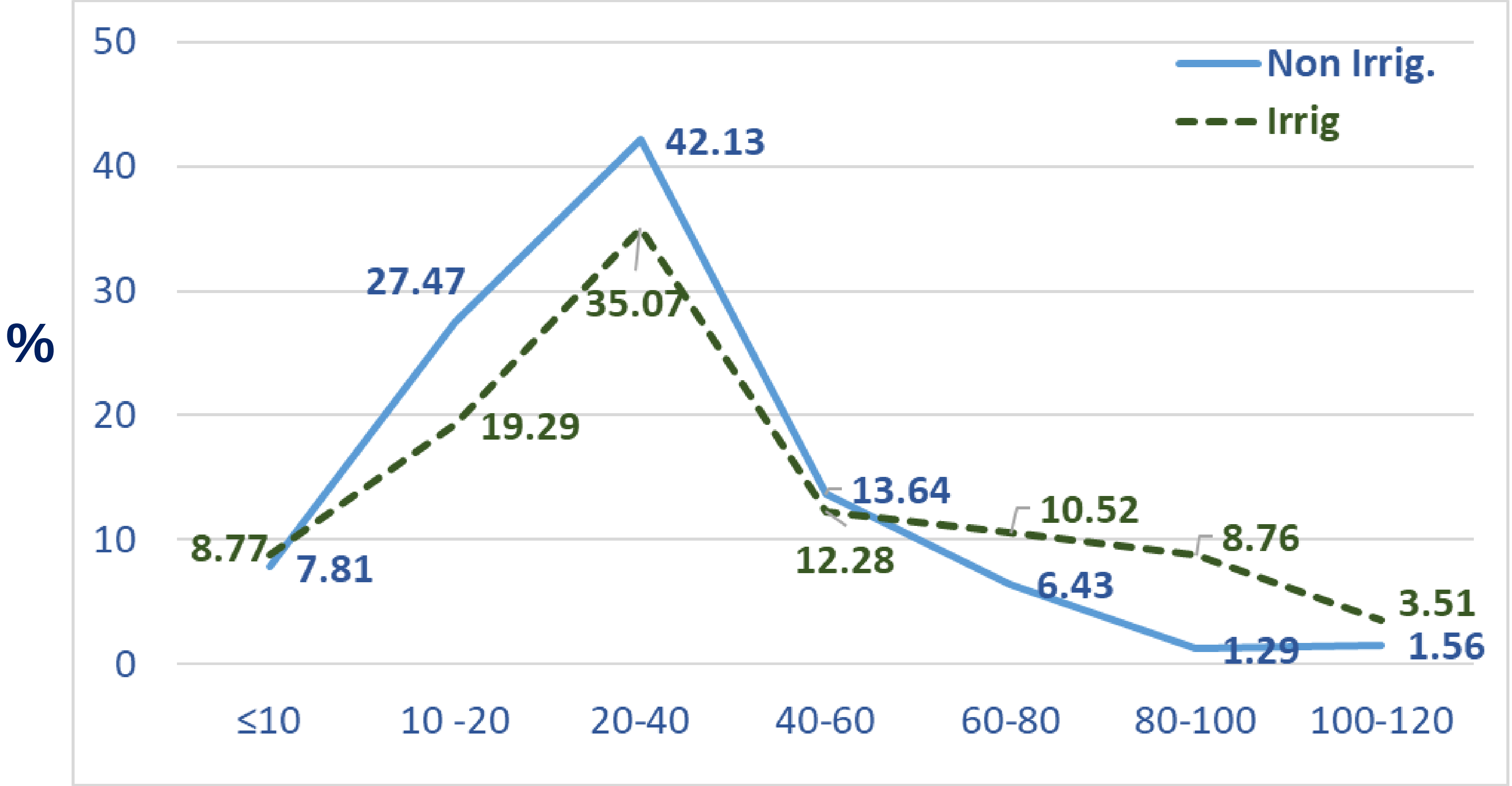
Rain fed community



Irrigated community

➢ Maize productivity and price

- N(Share) from total plots = 2350 (35.2% of the single stand crop plots=6671)
- Average productivity in Qt/Ha : Total = 32.8; Non Irrig = 32.5; Irrig. = 42.6
- Average price = 711 Birr/Qt



Productivity range in Qt/Ha

IRRIGATION MANAGEMENT IN SMALL-SCALE AGRICULTURE

EZANA ATSBEHA

WATER & FOOD SECURITY PROJECT PIRE

3RD ANNUAL MEETING

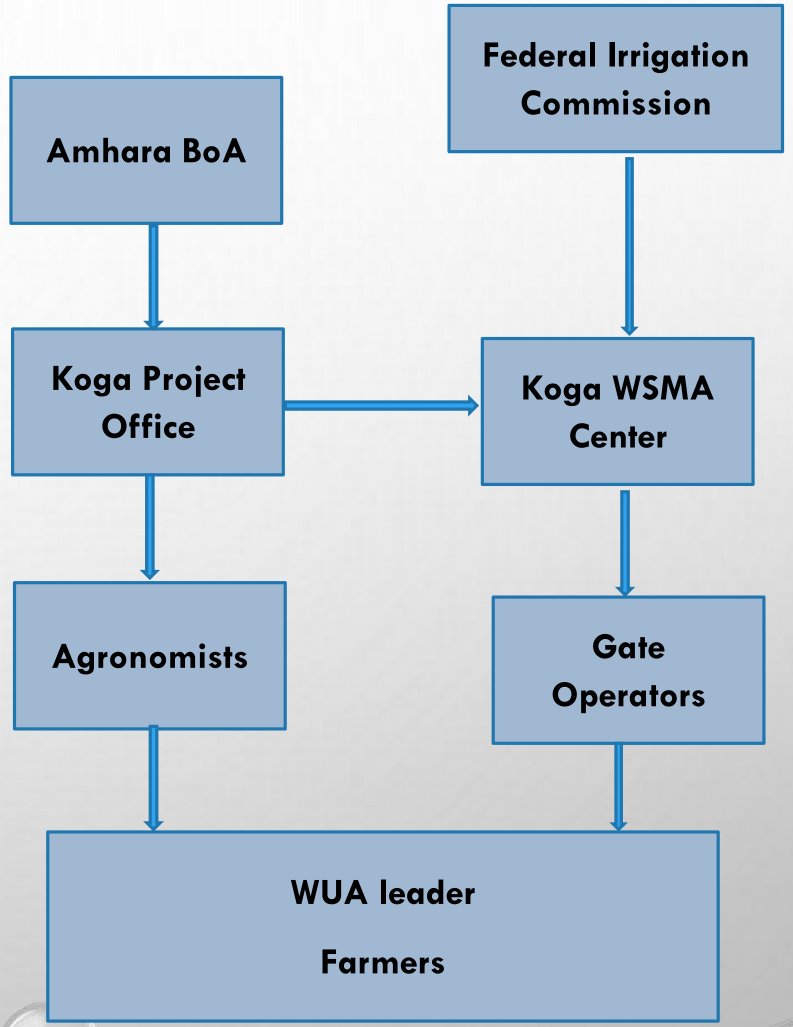
NOVEMBER 21 - 22, 2019

BACKGROUND

- Fieldwork
  - Seven months (January – July 2019) in Merawi, a small town in the North Mecha woreda
  - Short visits to Gaita Kebele, Dangila Woreda
- Data sources
  - Conversations with water administrators, farmers, and agricultural experts
  - Document review

IRRIGATION ACTORS

- Multiple actors and layer in irrigation management makes coordination difficult and causes inefficiency
  - Federal Irrigation Commission was perceived as being preoccupied with large dams
  - In October 2019, cannel maintenance bid was being floated, while water released was planned mid-October
  - Farmers argue that coordination between the Koga project office and WSMA is weak, contentious



RISK AND UNCERTAINTY

- **Weather**
  - In March 2019, the Koga Project Office sent a letter to all WUAs advising farmers not to plant crops for second irrigation as it feared that it will run out of water before the rains start and will not release adequate water. Many heeded the advise, but some planted anyway. It later turned out there was enough water, and also there were some rainy days in late April.
- **Sedimentation, infiltration**
  - Both experts and WUA are wary about sedimentation in the dam. Many were happy that the dam was already full in August 2019, but are uncertain if the water level is high because of sedimentation.
  - Farmers and experts in Gaita suspect that water is seeping much faster that it used to. Springs downstream fill up at the wrong time of the year, want to use infiltrometer.

MANAGING ACCESS

- **Access is strictly regulated**
  - No use of water pump
  - Schedule enforced
  - Attempt to prevent non-agricultural water uses

- **But farmer resistance**
  - Non-agricultural use of water – plaster mud
  - Non-food crop use of water – Qat, eucalyptus
  - Tamper with physical structures

In [x] kebele, farmers found a wrench that was lost by the gate operators, and they started opening the TC gate at night…. When we found out about that, we gave them a warning. But they did it again and we shut the gate off to punish this farmers until they hand over the wrench. But the administration instructed us to open the gate. I refused. I informed the Koga office about what has happened. The next day the farmers called me over to say that they have found the wrench and handed it over… [conversation with WUA leader]

MANAGING MAINTENANCE

- **Dam-secondary cannel level**
  - Watershed work
  - Delayed maintenance of roads, 1st and 2nd cannels, night storages, and gates
  - Farmer innovation – scheduling less daylight hours to TCs whose gates don't close fully
  - Capacity, coordination?

- **TC and below**
  - Cannel maintenance
  - Competing interests – grazing on cannel banks
  - Institutional issues?

PRODUCTION ISSUES

- **Administrators' logic versus farms logic in production**
  - **Administrators**: efficiency, market orientation
  - **Farmers**: security, multiple-use crops, hedging bets

In an annual report document, the Koga Project office characterizes the production of finger millet as a challenge to be overcome. It argues that farmers continue to produce it despite its long maturity period because farmers believe that it is good food crop, good for planting potato on the same land next, good cattle feed.

PRODUCTION

- New development in cropping patterns, necessitation change in water release amount and patterns.
    - In the previous kiremt, more than 4000 avocado trees were planted on 400 hectares of land. This might lead to higher water demand in Tikimt, Miazaia, and Ginbot

- Farm practices
    - Multiple corps, with varying water demands and maturity periods being cultivated poses challenges in water release.
    - Cluster planting attempted, but currently high risk due to lack of market linkage or processing/preservation

CONCLUSION

- Irrigation management is complicated due to uncertainty, institutional issues, and complex farm practices.
- Directions of research engagement
  - Refine ongoing forecast work – new crops, cropping cycle, etc.
  - Revisit framing of irrigation and food security – irrigation for what?
  - Explore cluster farming and avenues of storage procession – micro-grid work?

Working with Abay Basin Authority

Hawolti Curry

Faith.curry@uconn.edu

Question

How do relationships between scientist, farmers, water managers and authorities influence the production dissemination and outcome of new scientific knowledge?

Lines of Communication

Koga Dam Administration

Agronomist

Farmer Co-op

Administration Schedule vs. Union Needs

- Disconnect between traditional methods of forecasting in relation to water management
  - Koga Dam Admin Expectations
  - Farmer Co-ops and Union Needs

Research Contacts

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- Faith Hawolti Curry faith.curry@uconn.edu

Adoption and Dissemination of Agricultural Technologies: The Case of the Tractor in Dangishta Kebele

Kristen Kirksey & Selam Negatu

Water & Food Security PIRE Annual Meeting

November 21, 2019

Overview of presentation

- Types of technologies found in kebele
- Overview of tractor
- Primary findings:
  - Technology dissemination
  - Considerations in access and use of tractor
  - Opportunities

Solar pumps

Rope pumps

Improved ploughs

And many more!

- Solar water pumps
- Rope pump
- Improved plough
- PICS crop storage bags
- Improved stove
- Chemicals for zero tillage practice

Technology dissemination

- Sharing of experiences from other areas
- Observing crop outputs
- Extension agents
  - Sharing information
  - Creating access
  - Demonstration

Technology dissemination cont'd

- Word of mouth

"I used the services of a tractor last year. The productivity of the land was amazing. I got 90 kilos of maize from my small land. The tractor turned over the soil very well and was very conducive for cultivating maize...... I heard about it from another farmer who has a lot of contact with teachers. He suggested that I use a tractor to plough my field. And then I told my friend about the tractor" [March 22, Dangishta]

Considerations in access and use

- Cost: Oxen Vs Tractor
- Timing
- Topography
- Coordination

Considerations in access and use cont'd

- Limited service providers

"I will say there is a problem in the supply of technologies. People did register and waited a long time to use the services of the tractor. The tractor is very beneficial because it ploughed the land in one go which we would have previously been forced to plough 3-4 times. Secondly, it is better to pay 1000 birr for ½ hectare of land instead of buying oxen to plough the field. Furthermore, it also helps to mix the top soil which has lost its fertility with the soil from below. Hence, because the technology has such benefits I think it is very good but there is a great challenge and hardship to bring the technology to the area." [June 6, Dangishta]

Opportunities

- High demand and willingness to adopt new technologies
- Institutionalization through government provision
- Address labor issues

Thank you!

An Overview of the Water & Food Security PIRE Social Science Research

ELIZABETH HOLZER

ELIZABETH.HOLZER@UCONN.EDU

The Question

How do relationships between scientists, farmers, water managers, and authorities influence the production, dissemination, and outcome of new scientific knowledge?

Major Themes

ORDINARY EVERYDAY LIFE ⟷ OUR INTERVENTION

- Ordinary understandings of weather
- Ordinary agricultural practices
- Ordinary technological innovation
- Ordinary relationships between farmers, extension experts, other kebele authorities, woreda and regional officials, and local and foreign scientists

- What people want in a forecast
- What people understand our forecast to say
- How we disseminate our forecast
- What people do with our forecast and why

Data collection

QUALITATIVE DATA

Informational interviews: administrators, farmers, and other stakeholders

Semi-structured interviews: farmers

Ethnographic observations: primarily Kudmi and Dangishta with some data from Reem; observations from Gayta, ABA and NMA in progress.

Texts and photographs

-Stored in NVivo software database

QUANTITATIVE DATA

Kebele questionnaire: kebele administrators

Village questionnaire: community leaders

Household survey: farmers

-Stored in STATA

Choosing between data sources

You can't say give me the more correct and accurate information, alas.

Instead, ask yourselves: Do I want **simple averages** or **complex variations**?

-When do most people generally plant maize?

- Faster, easier to use, but misses variation and biases

-When do people plant maize, what are the major sources of variation (people, choices, crops), and what influences that decision-making?

- Slower, requires more time and expertise to use, may focus on outlier cases, but captures some variation and biases

Data collection by topic and source

	Complex variations		Simple averages →		
	Ethnographic observations	Qualitative interviews	Household surveys	Village-level interviews	Kebele-level interviews
Forecasting practices	X	X	X	X	X
Agro-climatic issues	X	X	X	X	X
Food security	X		X	X	X
Technology adoption	X				
Crop production	X	X	X	X	X
Community participation	X	X	X	X	X
Infrastructure	X			X	X
Wealth			X		
Livestock management			X		X
Pricing					X

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