NSF-PIRE Water and Food Security Project
Annual Meeting Report

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

UNIVERSITY OF CONNECTICUT 1881

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Background

Partnerships for International Research and Education (PIRE) is a program funded by the National Science Foundation (NSF) to promote innovative international projects that enhance the welfare of global citizens through science, research and education. The Water and Food Security PIRE project seeks to understand how the relationships between scientists, farmers, water managers and other authorities influence the production, dissemination, and outcome of new scientific knowledge. Drawing on strong collaborations with partners in Ethiopia, we are introducing improved forecast products in six field sites in the Blue Nile Basin, Ethiopia, while observing the social interactions that surround this transnational scientific intervention. The Blue Nile Basin (BNB) contributes ~65% of the Nile flow and its water management decisions deeply influence all of East Africa. It has the physical resources to drive regional economic growth through irrigated agriculture and hydropower development, but its vulnerability to exceptional hydrologic variability and sensitivity to regional and global climate change have limited this development. We hypothesize that although forecasts help mitigate risk, political-institutional constraints may impede the development and transfer of scientific knowledge to manage risk. To test this hypothesis, we developed a novel field experiment that identify key sources of variation in hydro-ecological vulnerability (rain-fed versus irrigated agriculture) and in political-institutional vulnerabilities: "open" communities that encourage voice and trust versus "closed" communities that do not as well as highly institutionalized (hydropower), moderately institutionalized (irrigated), and minimally institutionalized (rain-fed) sites. By capturing both hydro-ecological and political-institutional variation, we are able to test competing models of science: a "pure science" model (communities mostly vulnerable to climate variability benefit most from forecasts), institutional model (more institutionalized communities implement forecasts at higher rates), and political-institutional model (open communities will exhibit greater benefits than closed communities).

Our objectives are to: (i) improve seasonal hydrologic and crop yield forecasts at scales relevant to farmers and water managers; (ii) identify and reduce barriers to their effective dissemination and uptake; and (iii) train a new generation of global experts who recognize both the political-institutional and hydro-ecological dimensions of food-energy-water security problems, collaborate successfully with international partners, and communicate fairly and effectively with stakeholders from disparate backgrounds. Ultimately, we seek to develop a political-institutional model of science that links sociological and engineering methods in a people-centered approach to the human-climate-water-agricultural nexus.

Summary

The second Water and Food Security PIRE Annual Meeting took place on May 17 – May 18, 2018 at the International Food Policy Research Institute's headquarters in Washington, D.C. The meeting commenced with presentations by Dr. Peters Lidard from the NASA Goddard Space Flight Center, Micha Werner from UNESCO-IHE Institute for Water Education and Dr. Tsegay Wolde-Georgis from the University of Colorado, Boulder, followed by technical presentations by researchers from the University of Connecticut, University of Oklahoma, University of Wisconsin and IFPRI who presented their findings, action items and goals for the next year.

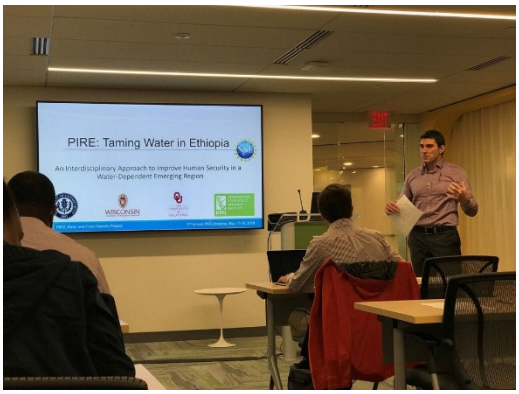
Action Items

Through the thoughtful discussion of all the participants, the following action items have been decided:

- Strengthen interlinkages between different project components with a special focus on integrating engineering and social science groups to make our knowledge production an even more cyclical process.
- Identify more clearly the information that is important for the farmers to include in the forecasting bulletin and explore ways to incorporate farmer's feedback back into the forecast.
- Identify what other existing forecasts might be available in the area (e.g. NASA).
- Engage local stakeholders in the process:
    - The National Meteorological Agency (NMA) by involving a PhD student that works at NMA in the project and arrange for them to visit UConn.
    - Contact the Agricultural Transformation Agency (ATA) and specifically Dr. Marcos Quinene.
    - Ask Girmachew Addisu, our contact at ABA, to connect us with people from the Bureau of agriculture (e.g. an Extension Head).
- Engage our European Partners in the project.

May 17, 2018

Introduction by Dr. Manos Anagnostou
University of Connecticut



Dr. Anagnostou opened the meeting informing the participants about the project rationale and goals and the general project framework. The overall purpose of this international research endeavor is the enhancement of crop and energy production in normal years and the minimization of losses during climatic extremes. The ability to work on problems that are global in nature and find solutions has been identified as one of the key goals in educational systems. The herein PIRE project is contributing towards building this capacity at the university level and sustaining programs that incorporates global aspects. The project includes a training program for undergraduate and graduate students at the US based institutions, who will work closely with Ethiopian faculty members and students, on the problem of water and food security. The Blue Nile region was selected as the project's area of focus, given that climate variability poses a challenge that affects the decisions and the lives of the people in the region. He recapped the four US Institutions, the two universities from Ethiopia and three from Europe involved in this project:

- University of Connecticut, University of Wisconsin, Oklahoma University and the International Food Policy Research Institute (IFPRI)
- Addis Ababa University and Bahir Dar University
- University of Kassel-Germany, University Joseph Fourier-France, University of Reading-UK

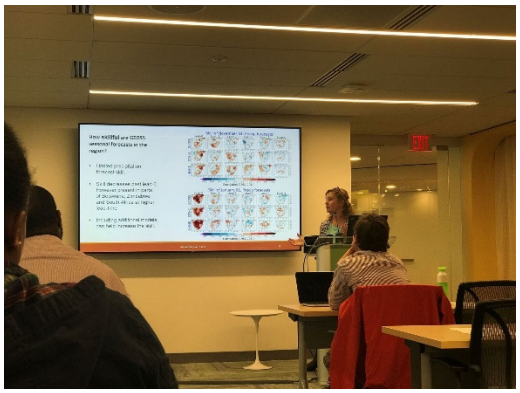
In addition, we have strong ties with these local stakeholders:

- Abbay Basin Authority (ABA)
- Ministry of Water, Irrigation and Energy
- National Meteorological Agency (NMA).

The project will lead to capacity building that will benefit local institutions. Ethiopia is an important case study due to the variability of precipitation, and the country's strong dependence on agricultural and energy production. The project's goal is to understand the relationships between scientists, farmers, managers and how their interactions affect the outcome of implementation of scientific knowledge, while challenging the belief

that"the best forecast will produce the best effect". The information produced during the project will eventually be used to inform policy.

Seasonal-Scale Drought Monitoring and Forecasting in Africa and the Middle East, Dr. Christa D. Peters Lidard NASA Goddard Space Flight Center Rapporteur: Dr. Zoi Dokou



Dr. Christa Peters-Lidard presented NASA's project on Seasonal-Scale Drought Monitoring and Forecasting in Africa and the Middle East, stating that the goal of the project is to develop a drought forecasting system to support FEWS NET's (Famine Early Warning System Network) food insecurity early warning efforts. She further elaborated on the technical components, FEWS NET LDAS (FLDAS) uses 2 LIS-based LSMs: Noah3.3 (10km x 10km resolution) and VIC 4.1.2 (25km x 25 km resolution). It takes as inputs meteorological information from MERRA-2, GDAS, CHIRPS, CHIRPS-prelim, RFE2 and provides daily and monthly outputs on the full water balance e.g. ET, SM, runoff Full energy balance e.g sensible heat flux, ground heat flux, net radiation. The strength of NASA's system are the following: high performance computing for data storage, hydrologic/land surface modeling and access to new and old remotely sensed data, and integration of these features with the LIS software. FLDAS drought monitoring is the main application that was presented by Dr. Peters-Lidard. The most important remote sensing input is MODIS – greenness in vegetation. The team is currently working on reservoir routing scheme, currently only surface water routing is available. The modeling system provides streamflow estimates, looks at a particular basin and normalizes based on historical context, and then provides seasonal forecasts.

Dr. Peters-Lidard also presented the FAME: Drought Forecasting Project: The Southern African Region Case. The question that this projects seeks to answer is: how well can we forecast drought and how better initial conditions from remote sensing can help *better* forecast drought? The approach taken in FAME involves 2 LSMs (1981-2016) which are open loop with no assimilation. Forecast IHCs (initial conditions) include the following: Forecast drought, Assimilate GRACE, Assimilate SM while the forecast experiments are for the following types: ESP and Dynamical. Soil moisture percentiles are used to detect agricultural drought. For example, the 2015 major drought was forecasted by the system. Agricultural (SM) drought in major production/surplus regions is of particular consequence for the region's food insecurity. Modeled SM can be a useful tool for monitoring.

The typical crop calendars for Southern Africa and Ethiopia were presented. The typical crop calendar for the western agricultural areas of Ethiopia in particular includes the following important seasons:

- Mid April – mid July: planting season
- June – mid September: Kiremt rains
- Mid July – mid September: Lean season
- September - October: Green Meher harvest
- October - January: Meher harvest

At the end of her presentation, Dr. Peters-Lidard highlighted two other NASA projects relevant to our PIRE project, first the *NASA Food Security and Agriculture Initiative: ROSES 2016: Earth Science Applications: Food Security and Agriculture - University of Maryland (PI: Inbal Becker-Reshef) whose* goal of this multisectoral project is to increase capacity in earth observations. The second project was *NASA Food Security and Agriculture Office at GSFC* where she is the lead, located at NASA Goddard Space Flight Center (GSFC). It is the primary interface between NASA and awardee(s). It provides support and administrative oversight, reporting and agreement compliance and will facilitate programmatic, technical, and scientific reach-back to NASA capabilities, if needed.

UNESCO - IHE Delft Institute for Water Education, Micha Werner
IHE Delft Institute for Water Education
Rapporteur: Dr. Zoi Dokou

Dr. Werner started his presentation by introducing UNESCO-IHE Institute for Water Education. The Institute is part of the UNESCO family focusing on Water Education established in 1957, it is the largest Water Education Institution in the world. Its main foci are: education, research and innovation and capacity building.

To do this complex interaction between universities and end-users are possible and a research driven approach versus problem driver approach is followed. Dr. Werner continued his talk by introducing the DEWFORA project, a drought forecasting and warning system in Africa. Some of the questions this project tries to answer are the following:

- What is the science available?
- What are the societal capabilities?
- How are they translated into capacity building?
- How can society benefit from the forecast?

The methodology followed by the DEWFORA approach involves the following steps: pre-processing of meteorological forcing (bias correction of precipitation and estimation of potential evaporation), hydrological forecasting (PCR-GLOBWB hydrological model and DELFT- FEWS forecasting shell) and predicting ensembles

of streamflow, soil moisture and other hydrological fluxes. It also has the ability to forecast dry spells and temperature heat index, which is a metric important for cattle. The models have good skill for temperature heat index but it is more difficult to predict dry spells.

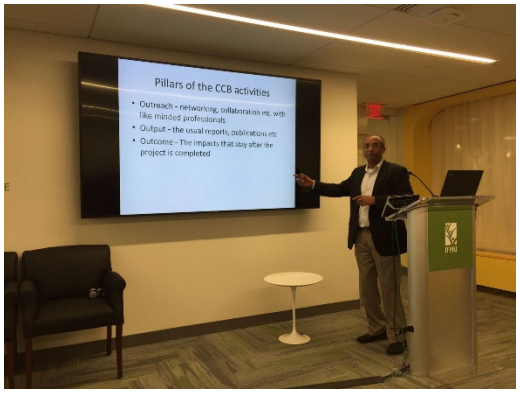
Based on the results, the following conclusions have been made:

- Hydrological drought indicators (e.g. SRI-6) can be predicted with skill at lead times of up to 5 months (for the wet season). In particular, skill is dominated by initial conditions for 2-3 months and by uncertainty in meteorological forcing at larger lead times
- ECMWF seasonal forecasts (S4) model provides most reliable forecasts – but approach using resampled climatology conditioned by ENSO is a close second
- Hydrological drought forecast provide variables such as levels in reservoirs – can be used e.g. by reservoir operators and irrigation districts

Dr. Werner also presented the project: *A4labs – Arid African Alluvial Aquifer Labs for securing water for development*. The aim of this project is to co-develop, test, share and compare methodologies to access a reliable and sustainable source of water for agriculture in Tekeze (Ethiopia), Mzingwane (Zimbabwe) and Limpopo (Mozambique), using water underlying dry river beds, and upscale these for use at river basin scale, while maintaining sustainable abstraction limits and minimising negative social and ecological impacts.

Capacity Building for Climate Change Adoption in Ethiopia and Lessons Learned, Tsegay Wolde-Georgis University of Colorado Boulder

Rapporteur: Dr. Zoi Dokou



Dr. Wolde-Georgis firstly introduced the *Consortium for Capacity Building, University of Colorado – Boulder*. The Consortium focuses on enhancing the value and use of climate, water and weather information for the betterment of societies and the wellbeing of individuals. Its main pillars are: outreach, output and outcome (impacts after the project is completed). "Climate is too important to leave it only to the scientists- everyone needs to be informed about it." Dr. Wolde-Georgis talked about the *Africa Union*, which was approved but not as planned – an example of poor communication with stakeholders. He continued with two funding opportunities that became available at the beginning of the decade, the first being the Open Society Institute – RFP, where he proposed graduate program and the second being Rockefeller Foundation – focus on smart agriculture. He is also involved in the *Ethiopian Institute of Climate and Society (EICS)*, established in 2012.

The Institute has 80 MSc students, 16 from other African countries and currently runs two programs: climate and society and Meteorology and Climate Risk Management. Dr. Wolde-Georgis also introduced the *Ethiopian Agricultural Transformation Agency (ATA),* established in 2011. The agency's aim is to transform Ethiopian smallholder agriculture and receives funding form Gates Foundation. The agency operates as a catalyst, reaching out to different organizations. It was initially well-funded, but the lack of funding of multiple other organizations has created an issue. Dr. Wolde-Georgis stressed the need to develop a different strategy to access climate information with focus on rain-fed agriculture. "The interest in climate becomes important only after the fact- after there is drought", he says. It is important to shift the entry point of climate from disaster to the extension. There are extension workers at the community level. Lastly, Dr. Wolde-Georgis presented the "The Victory Gardens Project". Under this project his team introduced fruits in dry lands with the aim to diversify food sources. Particularly, 100 apple trees were planted in 2010 using clay pots for irrigation. The project was highly successful, with a 97% tree survival rate.

Overview of the Social Science Dimensions, Ezana Atsbeha
University of Connecticut
Rapporteur: Dr. Zoi Dokou

Ezana presented on behalf of Dr. Elizabeth Holzer, Selam Negatu and Kristen Kirksey. He started his presentation by introducing an important limitation of scientific investigation: it is often treated as though it operates separately from the social world, but in truth, we all know that the creation and application of science is inseparable from social life. But especially when scientific enterprises are transnational there's a major risk that this scientific investigation will take the form of top-down development projects that undervalue local knowledge and treat farmers as both causes and victims of environmental problems rather than as social agents with their own constrained autonomy. The Water & Food Security PIRE proposes to test a *political-institutional model* of science that links sociological and engineering methods in a people-centered approach to the water-energy-food nexus. He continued by posing the following question, which is the main question this project strives to answer: How do the relationships between scientists, farmers, water managers, and other authorities influence the production, dissemination, and outcome of new scientific knowledge? Improved forecasts can help mitigate risk, and our goal as social scientists is to identify the political-institutional constraints that may impede not just the transfer of this knowledge but even its creation.

The social science team is developing a novel experiment that tests three competing models of scientific enterprise: a "pure science" model, an institutional model, and a political-institutional model. They plan to introduce the forecast-based guidance into five sites to test a "pure science" null hypothesis against institutional

and political-institutional hypotheses. Ultimately, they hypothesize that open communities will exhibit greater benefits than closed communities irrespective of hydro-agronomic variability; political-institutional factors such as voice, trust, and fair grievance practices will prove stronger than hydro-agronomic factors. The social scientists are using a mixed method approach to development this analysis, including household surveys with propensity-based matching to test hypothesis and multi-sited, longitudinal ethnographies to discover mechanisms that would drive the political institutional outcomes. Furthermore, Ezana talked about the work the social science team performed last summer (2017). Three of the social science graduate students, Ezana, Selam and Berihun conducted preliminary fieldwork in Bahir Dar, conducting 48 interviews in 7 communities across six Woredas. This included interviews with farmers as well as Woreda (district) and Kebele (neighborhood) level agricultural experts, Woreda and Kebele administrators, bureau heads and staff members including Amhara region agriculture bureau deputy head, the trade, industry bureau and marketing section head as well as the Water Resource Bureau irrigation project management head. Ezana then presented their working hypothesis which is that Reem and Gaita will exhibit greater benefits than Kudmi and Dangishta; even with improved forecast-based information at the farm scale, political-institutional factors such as voice, trust, and fair grievance practices will prove stronger than hydro-agronomic factors. In contrast to an institutional model of science, which would predict that Fincha Dam, Reem and Kudmi would implement forecasts at higher rates, we hypothesize that Reem and Gaiti will implement forecasts at a higher rate than closed institutions.

Integration of Agro-Climatic Information for Household Survey Sampling Design, Berihun Tefera
University of Connecticut
Rapporteur: Dr. Zoi Dokou

Berihun Adugna talked about the preliminary field assessment of the study area and identification of treatment areas (Woredas and Kebeles) in Summer 2017 with the social science team. During this field trip important information was collected to guide the sampling design and the design of the draft questionnaire and data sheets. He presented the proposed methodology for the refinement of sample and sampling design (selection of villages and households), the total sample size and budget estimation for the survey and a first draft of the questionnaire and data sheets. The household level questionnaire, which is currently 16 pages, with 10 sections & 15 sub-sections contains the following information: identification, household profile, land resource ownership & use, crop production and management, livestock production and management, household expenditure, non-farm enterprise and food security, agro-climatic information, housing, water supply, sanitation

& energy, institutions and infrastructures, community participation & decision making. He also talked about the proposed data sheets for the Kebele and village levels. Next steps include the following activities, to be done in collaboration with other researchers in the project: a) finalizing the draft questionnaire and get ready for pretest. b) selection of four control kebeles, c) kebele and village level data collection, d) household level questionnaire pretest, e) adjustment of questionnaire and conducting field survey in 2019 f) data entry and analysis, h) literature review and write up of research reports.

Questions & Answers Session

Dr. Liang You: How would information flow be restricted between treated and control groups?

Berihun Tefera: Some information flow is expected but it will be minimized.

Dr. Micha Werner: There is also an existing forecast. How do you make sure that the non-treated doesn't get a forecast that provides the same information?

Ezana Atsbeha: The forecast is not useless; the logic of the research is that we have a baseline forecasting and then add another layer of tailored forecasting. What are some reasons for not sharing information when asking for example about agricultural yields? For example, people do not want to share for tax reasons.

Dr. Manos Anagnostou: We are still debating what the methods should be. Control vs treated communities is something we need to discuss in depth and how the circumstances (e.g. all normal years) affect the results. There is a lot to take into consideration and how they all tie to process oriented studies and how to scale up to make the ABM a useful tool.

Seasonal Forecasts and Application to Sectoral Decision-Making, Dr. Paul Block
University of Wisconsin - Madison
Rapporteur: Dr. Zoi Dokou

Dr. Paul Block presented on behalf of his students Shu Wu and Sarah Alexander. Dr. Block mentioned the qualitative and quantitative benefits of using seasonal forecast in decision making and the factors influencing them. Addressing the sectoral significance of Ethiopia, he mentioned that agriculture is a major component contributing to the GDP of the country. Then he presented precipitation forecasts at different resolutions. Sarah Alexander developed a statistical framework (both deterministic and probabilistic) for prediction of JJAS precipitation using CHIRPS observation. She showed the skill of the deterministic prediction. Using June 1 prediction, she showed a distribution of the periods at which the reservoir fills versus does not fill. She presented how to optimize reservoir operation by coupling statistical streamflow forecasts with reservoir simulation model followed by an outlook of 2018 forecast. According to the current prediction for the Blue-Nile Basin (BNB), as well as for Koga and Finchaa, near-normal to moderately wet conditions is expected to prevail over the year 2018. The deterministic prediction showed that the expected rainfall total in JJAS for 2018

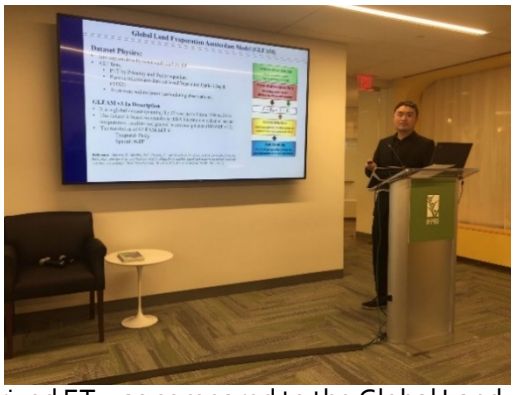
are 977, 1123, and 1027 mm, respectively for BNB, Koga, and Finchaa areas. Shu Wu applied Analog Model for hindcast evaluation of JJAS precipitation from 1981-2016 and found that coefficient of correlation of his model is 0.46 when compared against CHIRPS dataset.

Dynamical Analysis and Prediction Data for the PIRE Project, Dr. Malaquias Pena
University of Connecticut
Rapporteur: Dr. Zoi Dokou

Dr. Malaquias Pena provided an overview of on-going research within his research group and a list of the data that his group downloaded and processed for use by his group, 'CREST' modeling group and other potential users. He presented a figure showing NMME precipitation anomalies obtained as an average of over 100 ensemble runs for June through August, 2018 initialized between 1-8th of May, 2018. The anomaly values range from 0.5 to 1.0 mm/day over BNB. He compared correlation of NMME and CHIRPS precipitation for MJJ season during 1983-2016 with different lead times ranging from 0-4 months. Over BNB, the correlation varies from -0.40 to +0.50 with a lead of 0 month, which worsens up to -0.70 with a lead time of 4 months, thus stressing the needs for more caution while using these forecasts. He showed that CHIRPS MJJ climatology over BNB varies from 300-1000 mm. He provided an overview of the results of bias correction method being applied to the 6-hr forecast out to 7 months initiated during 1-8th of March, 2018 to force 'CREST' model.

Watershed Modeling, Xinyi Shen
University of Connecticut
Rapporteur: Dr. Zoi Dokou

Dr. Shen presented the results from the watershed modeling simulations that were carried out for the Upper Blue Nile basin. Evapotranspiration (ET) and streamflow water cycle components derived using a distributed hyper-resolution hydrological model, named Coupled Routing and Excess STorage Soil-Vegetation-Atmosphere (CREST-SVA) (Shen and Anagnostou, 2017) were evaluated. The simulation was carried out for a long period (35 years) at fine spatiotemporal resolution 500m and 3 hourly), driven by ERA-Interim atmospheric reanalysis (ECMWF) and MSWEP (Beck et al., 2017a) (blended precipitation product. CREST derived ET was compared to the Global Land

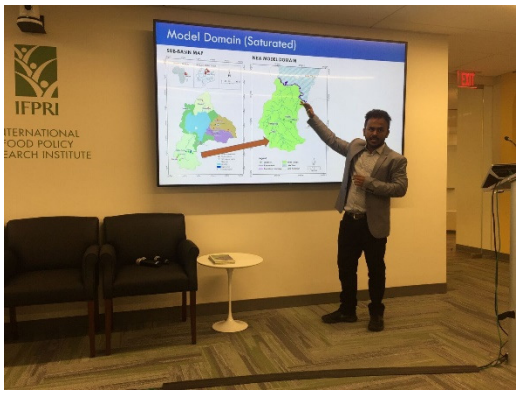


Evaporation Amsterdam Model (GLEAM) in terms of basin-average daily Actual Evapotranspiration (AET). Preliminary results showed correlation coefficient, NSCE and relative bias of 0.93, 0.81 and 4.33%, respectively. The streamflow is currently validated against observed data at different basin scales.

Questions & Answers Session

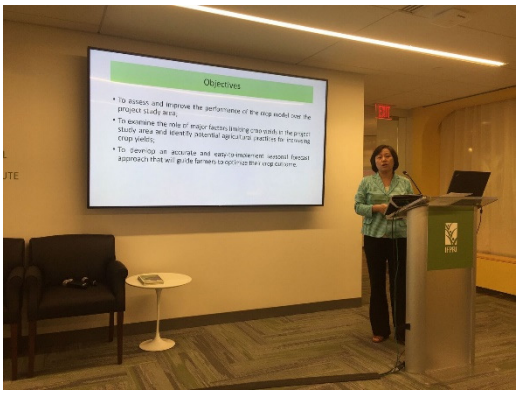
Dr. Christa Peters- Lidard: suggested to assimilate SMOS/SMAP into the model and mentioned that there is a 9 km product going back to 2014.

Approach, Challenges and Updates on Local Groundwater Model, Fahad Khadim
University of Connecticut
Rapporteur: Dr. Zoi Dokou



Fahad Khadim presented his objective of developing and applying a calibration ground water model so that seasonal forecasts could be carried out. In order to accomplish this, release and abstraction scenarios for the irrigated sites needed to be incorporated in the model. The model is set up using topography, aquifer characteristics, hydrological features and other spatial properties. Using Python scripts to facilitate the automation of the model, which entails assimilating of in-situ water levels, simulated water balance data and streamflow data for the CREST-SVA model. The model has three scales; regional which is comprised of the Abbay Basin, intermediate scale comprised of the Tana Basin and the local scale, which focuses on four communities. He summarized the available in-situ data and boundary conditions which will be validated against the citizen science data. Major challenges of his work included selecting the appropriate spatial zoning of hydraulic conductivity, addressing the hydrogeological heterogeneity in the model and adequately setting up the initial conditions which he ultimately decided to blend with groundwater contours from literature. He finished with a progress report indicating the ongoing status of calibrating the local model and the preparations for the dry run of the model forecasting system.

Crop Yield Modeling, Guiling Wang
University of Connecticut
Rapporteur: Dr. Zoi Dokou



Dr. Guiling Wang presented research on the crop yield modeling at the four selected field sites. She started her presentation by stating that the model is not capturing inter-annual variability according to her expectations. Her research team looked at the correlation between modeled yield and climate variables. Based on the model results, in the Kudmi site for example, although crop yields depend on all model variables, the correlation is not very high between these variables and simulated yields. In general, the model results showed positive correlations with solar radiation and temperature, and negative for precipitation, which was initially a counterintuitive result. She indicated that for example precipitation in this region is larger than 800 mm, much higher than what is needed to grow maze. This is the reason why we see this negative correlation between precipitation and yield. She then continued that using the rainfall amount that fell before the rainy season gets the best model skill. As such this can be an important indicator. Of course, human reaction to climate conditions dictates the inter-annual variability yields which cannot be captured by the model. In this case, while water is not a limiting factor for crop growth, human decisions such as increased fertilizer could significantly increase maize yield.

Questions & Answers Session

Dr. Manos Anagnostou: If we use the initial state of soil moisture from a land Surface Model, we can have a better handle of the physical processes one month ahead; it's the dynamics of the soil moisture that dictate that field.

Ezana Atsbeha: The important period is mid-May to mid-June. The preparation of the plots starts in mid-April.

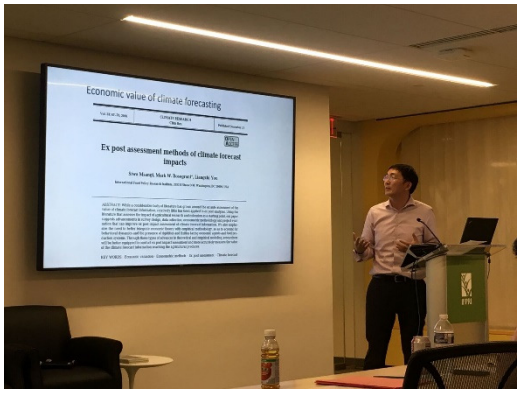
Dr. Manos Anagnostou: How do farmers decide when to start planting?

Ezana Atsbeha: A practical way to find when the field is ready for planting is to measure how much the ox's feet sink in the field. If they wait too long and the field becomes very wet, it is difficult to work on the field, and it is difficult for the seeds to remain in the field; they get washed away.

Dr. Christa Peters- Lidard: A lot of effort should go towards estimating the start of season because you need to be able to germinate the fields. A suggestion would be to run the model for devastating years (historical droughts) and see if the model fails to germinate. This way the model can be tested in anomalous conditions. It's the timing that really matters.

Dr. Semu Moges: In Ethiopia, most failures actually occur during the growing season. Planting is not an individual decision; it is a community decision. Leaders make the decisions; someone decides and the rest follow. Many farmers distribute their seeds; they plant in June or May.

Impact of Seasonal Climate Forecasting: A Spatial Multi Market Model Analysis, Liang You
International Food Policy Research Institute
Rapporteur: Dr. Zoi Dokou



Dr. You started presented the Ethiopian multi-market model, which is currently used in the PIRE project. The model was originally developed by IFPRI and has been further improved by Paul Block. Some of the agricultural commodities included in the model related to agricultural products of interest to the project are: maize, teff, wheat, sorghum, barley, millet, oats and rice. The model uses prediction to reallocate agricultural land choices for example from maize to teff. Interestingly, when reallocating from maize to teff, no positive GDP benefit is apparent in any year. While spatial variability could play a role – there might be positive net benefits for zones with extremely dry conditions, thus it becomes beneficial to grow teff instead. Dr. You also presented model results showing the average calorie change vs price effect. Based on the results, calories from teff consumption decrease gradually due to a lower supply as more maize is planted instead, however the calorie change becomes relatively constant at -46 Cal at a reallocating percentage of 55%. In summary, Dr. You concluded that climate variability has large impact on the economy in Ethiopia and seasonal climate forecasting has impact on farmers' decision making and livelihood. 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. A limitation is that only one scenario is explored so far. More realistic scenarios will be explored after the sociological experiments and surveys are conducted and the ABM model results are incorporated.

Agent-Based Modeling, Sardor Musayev
University of Connecticut
Rapporteur: Dr. Zoi Dokou

The objective of the work presented by Sardor Musayev is to use agent-based modeling (ABM) to link physical and social systems for a broader view of how uptake, assimilation and exchange of information from scientists to various stakeholders may occur, and to identify patterns and barriers to adoption of forecast information.

Sardor Musayev's presentation was an interactive way of showing how an ABM model works by first identifying who the stakeholders are (water managers, smallholder farmers, development agents etc.) and what are their behaviors and interactions are i.e. how they are likely to receive and transmit hydroclimatological information and what actions they will take in response to the information. This information will be collected through in-depth focus groups and surveys. Using this information, the research team will develop the ABM to understand the flow of information, the likelihood of acceptance and transmission to other agents, and factors influencing these processes. Moreover, the ABM will be coupled with agricultural productivity models to predict agricultural yields based on different climatological conditions and forecasts. The resulting yields can then be fed back into the ABM input and will influence farmer decisions in subsequent model years.

Citizen Science, Dr. Zoi Dokou
University of Connecticut
Rapporteur: Sardor Musayev

Dr. Dokou presented the importance and updates of the Citizen Science component of the PIRE Project. She spoke of how eagerly high school students participate with the support of graduate students from Bahir Dar University. They were engaged in collecting data and measurements of river stage, groundwater level and soil moisture content. These data can be integrated into other project models and contribute to crop yield model. She spoke about the future plans on involving farmers and possibly general public into citizen science engagements. There was discussion on how the soil moisture sensor developed by Dr. Li's group, helps local farmers and their involvement in citizen science. Micha Werner mentioned Ground Truth (http://gt20.eu) which has the same kind of involvement of the general public in data collection in various European and African countries (not including Ethiopia). Dr. Anagnostou talked about the importance of citizen science and the EGU (European Geophysical Union) meeting dedication of a whole session for it.

E-Ping App, Dr. Yang Hong
University of Oklahoma
Rapporteur: Sardor Musayev

Dr. Yang Hong presented E-ping, a weather application developed by his group for IOS and Android smart phone systems and m-Ping characteristics and current usages by local citizens in the USA. Dr. Hong encouraged participants to download the app from App Store and test it. Participants actively took part in this interactive session. He showed an online video on app usage instructions with easy user interfaces. He talked about report types and current weather information, different historical versus current citizen reporters. Images can also be uploaded into the program to depict the severity of the event. He also presented the BWING (Blue Nile Weather Identification Near the Ground) app objectives and data collection system. Language settings have been developed in English and Amharic. This app also gives users the ability to analyze the data and report options. The app is currently developed only for IOS but plans are, to extend it to Android systems as well. There is also a website version of B-WING (http://bwing.io). Interested users can access the website to further reading of weather applications.

May 18, 2018

Principal Investigators/Advisory Board Meeting
Rapporteur: Dr. Zoi Dokou

Dr. Anagnostou opened the meeting by summarizing the group's expectations of the Advisory Board Members. He asked for members to provide their opinions, comments and suggestions on the research and educational aspects of the project and summarize them in the form of a report. This report is to be shared with our NSF program manager who is very interested in the advisory board member's feedback on our project. In addition, Dr. Anagnostou asked the advisory board members to provide suggestions of researchers and research groups that are doing related work and we could collaborate with. He continued that we would like our advisory board to recommend products outside this project that we could look at and potentially include. For example, for the crop yield model, is there a Land Surface Model that can provide real time soil moisture data? We do not have to rely only on our own forecast. We would like to interact with key people working on this. This is as much as understanding the utility of this information as the information itself.

The main points of the discussion that followed are summarized here.

Research framework

Dr. Peters-Lidard suggested that two aspects of the research framework need to be clearer. On the engineering side, what needs more clarity is how all the different models fit together. On the social side, what needs to be clearer is how information flows: how do the households get food and how do you break down sociologically each of the types of domain within which the relevant information flows are operating. Dr. Werner suggested adapting a more iterative structure in our project to make things the social scientists uncover more central to the project as it progresses.

Seasonal forecasting

A suggestion was made by Dr. Werner that instead of creating our own forecasts we could strengthen the existing forecasts instead. In his opinion, the innovation is not on the actual forecast but on the way it is disseminated and up taken by the farmers and water managers.

Dr. Anagnostou commented on the above, saying that it is not expected of us to sustain a seasonal forecast in Ethiopia; it will be an added value to what NASA and European agencies are providing. Dr. Anagnostou commented that we really need to think what information we will include on the forecast bulletin and how it compares with the existing forecast. We will not be issuing forecasts we would like to build a link to NASA for example to pick it up, and make it operational.

One concern that was raised for the forecast-based information is that it might be difficult to get a clear signal between the treated/control sites.

He then continued by providing some additional information about the social science investigations to provide some clarity on the research framework we propose: The ethnographers will be in Ethiopia for a year (during the entire wet season and part of the dry season) so they will investigate the farmers' reaction to the forecast. They will go again the following year (during both the wet and dry seasons) and potentially for a third year. We hope that the data we collect longitudinally will help identify what changes need to be made to the forecast, especially since we will have observations before and after the forecast dissemination. While the ethnographers are in the field, we will have focus group discussions, to identify these changes.

Dr. Wolde-Georgis mentioned that one of the things we need to take into consideration are the 50,000 extension (or development) agents (natural resources, cereal, livestock, gender). They are the entry points to the village. One of the things they do is translating the forecast, which they receive from Ministry of Agriculture, to the farmers. Understanding the way the forecast is currently disseminated is important. Farmers don't have many options of making their own decisions. So, training the extension agents is suggested.

Dr. Werner mentioned that an important question is how to feedback into the forecast the information that farmers are providing and what information is important for them (e.g. onset of rain - medium range forecast is very good for this).

Dr. Wolde-Georgis provided some more detailed information on the farmer practices and decision making in Ethiopia. He mentioned in Ethiopia farmers do not really use the forecast for seeding. It becomes more important at the end of the harvest season. Talking with ATA will give us more information on this. Monitoring is also very important (soil moisture conditions) for deciding when to plant. Farmers have changed their practices; they used to be many varieties of seeds; now they variety is limited. Decision are made long before the growing season. This is why our forecast will start in January. Finding out what information the farmers would like to know and what decisions they make are key points.

Dr. You commented that there can be different needs and views depending on the institution eg. NSF focuses on process understanding but from IFPRI's standpoint impact and capacity building are more important. Thus, it is critical to focus on what the goal of the project is; given NSF's aims and goals for PIRE projects.

Stakeholder involvement

Dr. Block started a discussion on the importance of involving the local stakeholders and particularly NMA and ABA in our project. These partnerships need to be formed from the beginning. Dr. Wolde-Georgis continued that the law in Ethiopia is that climate information should come only from the NMA. As such our forecast needs to have the blessing of the NMA; and asked if that would be possible. Involving them in the process would be one way to do this. There are many opportunities for capacity building. For example, involving a PhD student that works at NMA in the project, train them and invite them to UConn or UW to work on seasonal forecasting.

ABA is mandated to control the Blue Nile water; they don't feel they have enough capacity to make these decisions. If through these collaborations, they will build capacity and feel more confident in making decisions that would be an important outcome of our project. They have lots of interest in our models.

Other agencies we could contact are:

1. ATA (Agricultural Transformation Agency). ATA has a household irrigation project in the area, focusing on rain-fed agriculture, so an entry point would be through our forecast. Khalid Bomba, is very focused with his mission; we have to be very careful with the entry point to attract his interest. The key would be to identify tangible impacts.
2. IOF- Consortium
3. The Regional Bureau of Agriculture, which receives weekly reports about rainfall, pests, disasters etc
4. The Ministry of Agriculture

5. Water user associations
6. The Red Cross, who is interested for forecast-based financing (for insurance purposes).

Dr. Anagnostou suggested to place one of the ethnographers at the institutional level in one of these agencies preferably within ATA or the Ministry of Agriculture to monitor their discussions and decision making process.

Education and Citizen Science

One of the things we are actively pursuing is to involve more undergraduate students, especially from underrepresented groups, in our project. Regarding our graduate students, a suggestion is to pair US based graduate students with Ethiopian graduate students.

For the high school students involved in the citizen science initiative we could provide incentives to them e.g to go to Bahir Dar University, Addis Ababa University or even come to US to present their work related to the collection and analysis of the citizen science data.

We might need to move to open source codes and apps. Having simple, text based delivery of data might be more applicable for Ethiopia. We could buy a data plan for the users (potentially the extension agents) costing about 500 birr per month. The training on the app can be part of the summer school.

Data and models

Some important points discussed regarding the use and availability of data and models are summarized below:

- We have currently tipping bucket rain gauges installed which is an independent set of data not used in blended products of precipitation.
- There exists a radar in the Bahir Dar area which is not currently used – we would like to provide support to NMA to utilize it – this is something to discuss during our upcoming visit to Ethiopia. The radar information could be used to calibrate satellite products.
- WaterGAP could provide input for the lake and reservoir management.
- We could focus on the assimilation of different types of data (irregular observations).
- There are many different and creative ways to detect rainfall. e.g using windshield wiper data and based on the car speed, the intensity of rain was estimated (HESS paper suggested by Dr. Peters-Lidard). We could experiment on using twitter to tweet if there is rain to test the forecast.

Action Items from Advisory Board Meeting

- Identify interlinkages between different project components (forecast group, sociology group) and making it a cyclical process.
- Identify what information is important for the farmers and include it in the forecasting bulletin

- Explore ways to incorporate farmer's feedback back into the forecast
- Identifying what other existing forecasts might be available in the area
- Forecasting bulletin design – potentially involving someone external to the project (e.g. a graphic designer) to do the design
- Engage local stakeholders in the process:
    - NMA by involving a PhD student that works at NMA in the project and arrange for them to visit UConn. Contact
    - ATA and specifically Dr. Marcos Quinene
    - Ask Girmachew Addisu, our contact at ABA, to connect us with someone from the Bureau of agriculture (e.g. an Extension Head).

Breakout Session 1: Citizen Science, Education and Training
Rapporteur: Selam Negatu

Introduction to the day's session was made by Dr. Anagnostou. He indicated that some of the issues NSF has highlighted as an important area to put emphasis on include engagement of US student, the frequency of interaction, exchange of information and finding ways of collaboration with Ethiopian students.

Citizen Science, Education and Training (CSET) is an important aspect of the project as it informs the way we translate, transform our understanding of forecast and related information to locals as well as others who may be interested in similar research areas.

Dr. Anagnostou asked the group to think about what are the challenges and mode of operation, the frequency of the brown bag, topics for discussion, establishing a list of themes for the next meetings, how undergraduates connect with graduate students at UConn as well as students in Oklahoma University and the University of Wisconsin. Additionally, he asked to have a discussion on things that the graduate students would like to be included or offered in the summer school should be covered. The summer school should be a two way experiential and information sharing process. Students should give a presentation while faculty are also expected to give short lectures and share their experiences, include speakers from institutional collaborators as well as stakeholders.

Graduate and undergraduate students from Bahir Dar University, as well as US universities, will be involved in the summer school. But people who can cover their expenses for the summer course can also be offered the opportunity to participate as well.

Let us throw ideas and share information about the brownbag, what you want to cover, news highlights etc. You can think about social science team interpreting the presentation of the engineering team and vice versa and provide a summary that could be posted on the project website.

1. **PIRE Brownbag Sessions**

Kristen Kirksey who has been organizing the brownbag sessions indicated two meetings have been organized for this year one focusing on reports on information gathered and activities undertaken during the summer fieldwork while the second session included two presentations by Meijian Young and Sarah Alexander on their ongoing projects.

The brownbag was reported by participants to be beneficial but the event is suggested to be organized more frequently. Fahad Khadim suggested holding the brownbag once a month and setting up goals each meeting for subsequent sessions to make it more structured and organized.

Some of the advantage of brownbag listed include;

- As it is hard to know what everyone is working on especially as all participants are not located in the same university, having an overview version of what everyone is doing and following up through brownbag helps instead of simply meeting up like this once a year.
- Helpful and informative to connect and know about social science and engineering research.
- Helpful to figure out how one team's work fits into the other which leads us to achieve the overall goal of the project.
- Since people are from different disciplines they can also offer different perspective and comments on researches that are undertaken by social science and engineering teams.
- Good for monitoring and evaluation of progress made by students.
- Helps to improve communication and presentation skills.
- Participants suggested to set up a standing schedule for the brownbag instead of setting up doddle poll trying to find dates that work for everyone. Identification of a standing day and possible topics for discussion is suggested to be carried out at the beginning of August 2018. Additionally, it should also include presentation schedules which combine works from social sciences and engineering teams. Participant of this sessions must also take an active part in the discussions, contribute questions and reflect on findings from each group's perspectives.

An example of what the hydrological team have been doing was shared to inform how the brownbag presentation could be organized.

Fahad stated "Hydrological team meets every two weeks and we present a graph we developed for example and share and discuss about it. Hence, we do not have to have a comprehensive presentation. For me, the brownbag session is the most important meeting than the other meetings we have in our separate groups"

- Participants also suggested that presentations must be broader rather than being technical in focus as brownbag participants do not have the same understanding of the technical vocabulary and aspect of each other's research works. According to Guiling Wang, "it is not good to focus on technical things. As participants, you must think about how I can make it interesting to people who are not in my field".
- Another suggestion is to share summary and questions from presenters before the brownbag session. Kristen suggests such information should be sent a couple of days ahead without adding extra work on presenters in order to facilitate and engage other participants in the discussion. Similarly, other participants should also forward their questions to presenters to facilitate discussions.
- Creating a social media account for the brownbag participant was also suggested. Primary sites such as LinkedIn and Research gate were selected as possible avenues for establishing this online group. Sardor Musayev was then selected to lead set-up this online group.

2. **Citizen Science, Education, and Training**

- The citizen science project is currently focused on involving the public on data collection. Students from Bahir Dar and selected high schools have been trained in conducting and measuring river stage, soil moisture, and groundwater data.
- According to Dr. Moges, data collected and used to develop interventions by experts, sometimes tends to not get implemented by farmers as they lack understanding or have been excluded from the actual data collection process. But having the community involved in data gathering and interpreting through citizen science facilitate uptake of intervention and facilitate information sharing between farmers and experts.
- So far participants of the Citizen Science have been engaged in gathering data on groundwater measures weekly, river stage measures daily during the wet season and daily/monthly measures of base flow information during the dry season.

- Speaking about the next step in the project Jon Mellor indicated soil moisture developed by Dr. Baikun Li, which offers multiple points more than what common sensors show (one layer coverage) will be deployed in the coming summer.
- Moving forward we must ask the following questions: How are farmers able to use this information? How this program influences the students who participate in Citizen Science? How is the data accurate? How can we better engage the students as well as letting them see how their contribution fits into the broader picture?

Questions and Answers Session

Muhammad Haider: Is there a specific schedule on how many points will be covered using the sensors?

Dr. Guiling Wang: We have talked about this already. One of the limitations we have is the number of sensors we can manufacture for Ethiopia. So far we have manufactured more than 100 and are scheduled to be used this summer. Hence, logistically it is difficult to gather information from the large area. Additionally, it is labor intensive to install and we also need to consider how far the students have to travel to do the reading.

Dr. Semu Moges: If you put a number of sensors in the field it becomes difficult for farmers to plow.

Dr. Guiling Wang: Sensors are set up after the land is prepared i.e., during the growing season and taken out before the harvest.

Muhammad Haider: Who actually uses the data? Who makes sure of the accuracy?

Dr. Semu Moges: We follow two approaches in gathering the data from the sensors. First, the students take up the reading at the same time an expert (MS student) will also take up reading and will corroborate the data. That is how it will be validated. We should also think about how we can tailor intervention/information sharing to the farmers and tie this with the citizen science part of the project. An example of such an effort made was offered as follows;

- We previously developed flood forecasting measures but did not know how to share this information with farmers. So we hired a social science team to study the means of communicating with farmers and they came up with 3 benchmarks height of kids, animals, and house to indicate flood level. This was color-coded to indicate the severity of the danger and they incorporated this to come up with ideas on how to exit when experiencing flooding. So we managed to code the solution in that way and the community was very engaged to the extent that they used to call me even at night to indicate the level of the flood using what we have developed. Hence, we must think of how best we can engage the social science team.

Suggestions

- It is important to think of ways to make information sharing using mobile phone easier as they may not be able to read and write. We must design figures to explain forecast for farmers as well as work in collaborative ways to share the technical forecast to farmer and information from farmers to the scientists. Two-way transfer of information must be made easier.
- We need to scale up girl's involvement and participation in CSET. Maybe involve mothers alongside daughter. Right now we have only one girl that is included in the citizen science team.
- It is very important to break a boundary that forces us to separately look at ourselves as the engineering and social science team. We need to start to look at ourselves as a team, as a whole.
- We have yet to address/deal with the social aspect thoroughly. For example, what does organizing boys and girls team together mean? Should we think of establishing an all-girls team separately? The social aspect of things is important to consider.
- It is important to know and familiarize ourselves with each other's language (vocabulary). In the course segment, it can be made a point to get us up to speed about each other's disciplines. We can add an introductory section to allow members to learn from one another.
- Add a vocabulary of the day in the brownbag session.
- Start a running google document/glossary so that people can add explanation and refer to them to understand what presenters want to communicate in their work (presentations).
- Add local languages that are commonly used and relevant such as *belge*, *kiremt* etc. along with explanation/description in the glossary.
- Prepare Citizen Science certificate for participants as well

3. **Summer school**

- It was suggested scheduling of the summer school, must not clash with data collection period during the planting season in 2019. This also applies to the schedule of students and farmers as well.
- We can hold one-day seminar closer to Bahir Dar for the farmers.
- Participants include faculty and graduate and some undergraduate students from Bahir Dar University as well as Universities in the United States.
- Suggested duration of summer school for one week.
- Give options to accommodate the different interest of participants by offering concurrent or chronological modules.

- The school must be more than a thought and as such must follow a hands-on approach to the training. For ABM one week is good enough time for the student to do their ABM that includes basic elements.
- Add some introduction to citizen science to show/as a way of linking sciences as well as-as an evidence/indicator of citizen interaction and engagement.
- Must identify who will be part of the steering committee that will organize the summer course and offer up-to-date information on the process.
- It is also important to begin the discussion and communication about the summer course with Bahir Dar to facilitate the delivery of the course and schedule around the availability of students as well.

Breakout Session 2: Forecasting Framework/Dry Run
Rapporteur: Ezana Atsbeha

For the dry run session - the objective was to discuss on where we would like to be, and what goals are we targeting to achieve for the dry run. The discussion with the advisory board led to ideas on the specifics of how to use the citizen science data and maintain consistencies/ efficiencies in performance, whether there are opportunities for frequent feedbacks, so that even in the forecast periods we can predict something in January and say, by March we can prepare for something else. Rather than annual cycles, the feedbacks and processes of updating how the model gets inputs from data should be done more frequently.

To supplement the dry run, suggestions were made to further improve/update the questionnaires so that the questionnaire includes more information on yields, pumping and other specific scientific information. It might be of interest to the project to add a separate component (in the questionnaire) to deal with crop impacts and the impact model in general. Meijian and Sardor were requested to prepare drafts on impact modelling.

Based on seasonal forecast and sequence of models, we have to now simulate for rainfed-areas. Dr. Wang said, the forecast is first to be carried out amongst ourselves (dry run), without delivering the information to the local people yet. Shu mentioned that they are working together with 6-8 statistical models and by next week they might have some forecasts ready for their other models. Sarah mentioned by next week some of the dynamic modelling information will be compiled by another group of people, who are working with literatures and other information. The plan for the dry run was to begin in June, as per the current proposal. The University of Wisconsin group and the crop modelling team are readily in the right technical shape to initiate the forecasting already. Dr. Wang added the context on how would we analyze the forecasts for teff - do we do spatial correlation with other crops based on other models or anything else. Meijian added that we might look at the correlations,

for example, in some other studies barley seemed to correlate with teff well and this might be considered as a basis for obtaining information for teff.

At the end, the idea was gathered that Meijian will look into different crop modelling initial conditions, and multiple initial soil moisture conditions because a variety of soil moisture initial conditions might have different outcomes. Shu mentioned, that for January through May they already have the forecast provided, they will do the same for JJAS but for crop modelling we can already use the forecast from January to May. With the same rainfall, we may check precisely the changes in yield which is caused by changes in soil moisture. The statistical model is validated based on means, so Shu suggested whether the total JJAS rainfall is sufficient for crop modelling.

A lot of discussions took place on groundwater modelling – basically in terms of knowledge sharing. Sarah asked, how the groundwater model will take place and help the crop model? It was discussed that the groundwater model will provide soil moisture data and reservoir levels, at local scale. Dr. Pena asked if we have time series observation data on groundwater levels, and the data limitations were discussed. The technical aspects of the Citizen Science project were discussed, and the significance of the field trip was addressed by everyone.

Dr. Wang added that that for the crop model two pieces of information are important. Soil moisture from the groundwater model, and the reservoir levels/ releases from the dam, especially in the dry season. And we have not reached to the irrigation component yet. Shu asked how we would forecast for crop yield values. Dr. Wang recommended that instead of identifying analogues using only precipitation, we should use radiation and temperature and other energy balance components to develop the analogues for the dry season. For example, doing one forecast for the wet season (based on precipitation) is fine but as for the dry season the precipitation is not significant we may broaden our criteria. Also, to reduce the number of variables for correlation, instead of using minimum temperature (T_min) and maximum temperature (T_max) we can use average temperature (T_ave), and then we have only two variables T (T_ave) and Radiation. Dr. Pena suggested if we can combine the T and Radiation variables into the ET, which we have in our model. Dr. Wang mentioned that they have similar plans for later. But physiologically, ET for the crops does not indicate the analogues, unlike the hydrological cases. However, for now, Shu and Meijian can check the correlation of ET and crop yields, and see what influences there of ET on the analogues are.

Dr. Moges mentioned, that the GLEAM datasets, the equation they use (Pristie Taylor) for ET is not relevant for the Blue Nile. The Penman equation is rather better. However, for actual ET the GLEAM is okay to use. Dr. Wang mentioned, we have the option to check multiple products in the final stage, and there are options to adjust our plans if one plan does not work in time.

The timeline for the dynamic model deliverables were asked, and Dr. Pena responded that they have six hourly data and it could be aggregated for daily scale. He can provide Dr. Wang the hindcast data of the past which will be helpful for Meijian, only to feed the minimal requirements. Sarah-Shu mentioned that they are preparing to have a blog where some of the forecast related data will be uploaded.

Breakout Session 3: Ethnographic Studies and Summer Survey

Rapporteur: Ezana Atsbeha

The session was opened with a general inquiry from Dr. Anagnostou regarding the necessary inputs for the ethnographic studies as well as the status of the questionnaire for the summer survey. The social science team reported that a draft household questionnaire and datasheets have been prepared, and first round of revisions have been conducted on the questionnaire.

Berihun presented the draft survey questionnaire. The questionnaire has ten sections, including background information on households, land ownership and use, crop and livestock production and management, irrigation practices, labor use, post-harvest handling and marketing, household expenditure, non-farm enterprise and food security, and agro-climatic information, among others. In addition, Berihun presented Kebele and village level datasheets. The presenter explained that plot level information in collected using the household questionnaire, and the data collected could be used for basic description of households as well as econometric analysis.

Various participants commented on the questionnaire length and focus. The meeting agreed that the questionnaire needed to be revised to make it more focused. Specifically, it was agreed that questions need to be directly linked to the overall project hypothesis and/or the data needs of specific teams. Ezana added that the summer presets a good opportunity to revise the questionnaire based on feedback from all team members.

Next, Dr. Mellor presented the ABM section of the questionnaire. Dr. Mellor explained that unlike a traditional survey, the ABM needs to generate a series of answers for the same question, most likely on a year to year basis, and thus might need to select a smaller sample for whom the questionnaire will be administered to be longitudinal.

In addition to the general comment to streamline the questionnaire, specific comments such as the need to include questions on planting dates, more questions on agro-climatic forecast, rearranging questions, and questions on type of fertilizers, were made by Dr. Holzer, Moges, Anagnostou, and Peña.

Finally, the meeting assigned Meijian Yang and Sardorbek Musayev to revise the sections related to crop modelling and ABM, and Berihun Tefera to integrate the revised questions into the draft questionnaire. Dr. Holzer and Ezana Atsbeha will conduct further revisions based on consultation with Ethiopian partners. Moreover, the meeting advised the PhD students to use the brown bag sessions to understand each other's data needs in greater detail.