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Climate information services to enhance agricultural resilience: Evidence from Ethiopia

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Abstract

Ethiopia is one of the most vulnerable countries in sub-Sahara Africa to the impacts of climate change and the unpredictability of climate variability. It has been deemed a climate "hotspot"—a place where a changing climate could pose grave threats to agricultural production, food security, and human well-being. Using two-rounds of 'Feed the Future' survey data that covers 3,799 farming households in five major regions in Ethiopia and employing panel data estimation methods, we analyze the potential impact of weather and climate services on agricultural productivity and farmers' resilience in Ethiopia. We found that access to weather and climate services increases the productivity of maize and wheat crops by 27% and 17%, respectively. These estimates are comparable to or higher than the conventional yield-increasing production technologies such as fertiliser and improved seeds. Despite such a strong productivity effect, access to CIS is limited-only 18% of the farmers. This study adds to the existing body of evidence on the significant positive impact of weather and climate services and affirms the importance of weather and climate information service products to enhance farmers' resilience to climate variability and change. Further analyses are needed to estimate the value to Ethiopia's smallholder farmers, especially those who are most vulnerable to climate-related hazards, of increasing investment in improving seasonal climate forecasts, mainstreaming weather and climate services in the agricultural extension system, including through National Framework for Climate Services (NFCS), and supporting farmer decision-making with climate-informed digital advisory tools and training.

Keywords: Weather and climate services; Agricultural productivity; Climate-related hazards to agriculture; Farmer's resilience; Climate change.

1. Introduction

Agriculture is among the sectors most vulnerable to weather and climate risks (WMO, 2016). Reviews of the linkage between climate change and smallholder farmers (e.g., Phiiri et al., 2016) shows that unless strategic interventions are implemented, climate variability and extreme events will affect smallholder farmer's agricultural yields. Given the significant and growing yield gap to the global average for major food crops and food security in sub-Saharan Africa (SSA), the role of Climate-Smart Agriculture (CSA) in improving agricultural productivity is becoming increasingly important (Zougmoré et al., 2018). This is particularly relevant for SSA economies such as Ethiopia, that rely heavily on subsistence and rainfed agriculture.

with significant

Ethiopia is considered among the most vulnerable SSA countries to the impacts of climate change and the unpredictability of climate variability (FDRE, 2017). Given that Ethiopia's economy heavily relies on weather-dependent agriculture, it is extremely susceptible to extreme weather events and gradual long-term climate risks and climate change. Even a slight change in weather conditions exposes a significant number of the country's population, especially those in resource-poor rural areas, to the risk of disaster, and climate change will continue to act as an agricultural risk multiplier exacerbating current vulnerabilities. Several studies (e.g., Shiferaw et al., 2014) have documented that extreme weather and rainfall variabilities have a considerable negative effect on agricultural GDP (e.g., Schlenker and Lobell, 2010; Borgomeo et al., 2017), household welfare (e.g., Deressa and Hassan, 2009), and national economic output especially in agricultural (e.g., Rowhani et al., 2011; Lesk et al., 2016). According to the Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index[1] (2017), the country is among the most vulnerable 10%. Weather and Climate Information Services (CIS) are increasingly seen as foundational for building resilience and adapting to the impacts of climate change on agriculture and other climate-sensitive sectors (Naab et al., 2019; Hansen et al., 2019).

The Global Framework for Climate Services (GFCS) aims to assure the provision of actionable CIS in all countries to better manage the risks and opportunities arising from climate variability

[1] The ND-Gain Country Index summarizes a country’s vulnerability to climate change and other global challenges in combination with its readiness to improve resilience.

and change, especially for those who are most vulnerable to climate-related hazards. This is often achieved by developing the National Framework for Climate Services (NFCS) and streamlining science-based climate information and prediction (WMO, 2012). Ethiopia recently unveiled its NFCS – a coordinating mechanism aligned with the GFCS - to enable the development and delivery of climate services across government agencies to improve risk management in planning, policy, and practice in consultation with agriculture and other relevant climate-sensitive sectors (NMA, 2021).

Effective use of weather and climate services, integrated with agrometeorological advisories, can reduce climate risks of farming communities and provide them with well-adapted guidance on the management of agro-climatic resources at the local level (FAO, 2019). Vaughan et al. (2019) reported that estimates of the impact of weather and climate services on agricultural productivity and farmer livelihoods are generally positive in SSA but that the existing body of evidence is few and far between and often affected by methodological challenges. There are a few studies that estimated the impact of CIS on agricultural crop productivity and/or farm income. However, most of these studies are either qualitative (e.g., Broad and Agrawala, 2000; Vogela et al., 2019), rely on non-representative data (e.g., Gebrehiwot and van der Veen, 2013; Oladele et al., 2018; Oyekale, 2015), focus on non-crop agriculture (e.g., Luseno et al., 2003; Egeru, 2016), or are the synthesis of literature reviews (e.g., Vaughan et al., 2019). Equipped with a slew of representative panel data and a widely accepted methodology, our study aims to fill this knowledge gap. We analyze the impact of weather and climate services on-farm productivity of major crops in Ethiopia: cereals, pulses, oilseeds, and coffee.
The paper is structured as follows. Section two describes data and methodology used, section three provides results from describtive and econometric analysis while the last section concludes.
. A.

Improving evidence on the impact of weather and climate services would guide national public and private sector actors, funding agencies, and international development partners to understand, counter and absorb climate-related shocks and build resilience, and determine the level of investment needed to improve the overall quality and range of weather and climate services provided to the community (WMO, 2015).

2. Methodology

2.1. Data

To estimate the effect of CIS on a host of outcome variables, we relied on a primary data from a large-scale survey implemented as part of a Feed the Future (FtF) survey conducted by USAID/Ethiopia and the International Food Policy Research Institute (IFPRI). The survey was undertaken across four major administrative regions of Ethiopia (i.e., Amhara, Oromia, Tigray, and SNNP) (Figure 1). In each region, zones[2] were selected based on USAID/Ethiopia's pre-identified so-called Zones of Influence (ZOI) covering 149 administrative woredas[3]. The FtF survey was undertaken as part of USAID/Ethiopia's Population-Based Survey (PBS) across these ZOIs. Covering only rural areas, these ZOI span three major agro-ecologies: 'moisture reliable', 'drought prone', and 'pastoral.' Data collection was conducted in three rounds (i.e., 2013, 2015, and 2018) for baseline, midline, and end-line survey, respectively. We have a total of 3,799 households for each survey round in 168 enumeration areas (EA). We collected data on CIS only in the end-line primarily due to the fact that a coordinated generation, translation, and dissemination of CIS only began in 2014 in Ethiopia. . We had the opportunity to include a climate services dedicated section in the endline survey. The questions include: (i) household's access to weather and climate services, (ii) types of weather and climate services provided, (iii) frequency and timing of weather and climate services delivery, and (iv) problems associated with the delivery of the services if any. The survey also provided data on other important variables such as household's socio-demographic characteristics, farming practices, use of labor (differentiated by age and gender groups) and production inputs (e.g., seed, fertilizer, chemical inputs), production practices (e.g., tilling, weeding, harvesting and technology adoption), marketing, and access to service centers. The households surveyed covered more than 55 different crop types ranging from major staple annual cereals (e.g., maize, *tef*, wheat, and sorghum) to perennial (e.g., coffee, fruits) crops. However, due to variations in the number of observations, our analysis focused on the four major crop types: cereals, pulses, oilseeds, and coffee. Among cereals, we focused our analysis on the most important

[2] The next administrative unit below regions
[3] The next administrative unit below zones

staple crops, i.e., maize, tef, wheat, and sorghum. In this paper, we employed the baseline and end-line rounds.

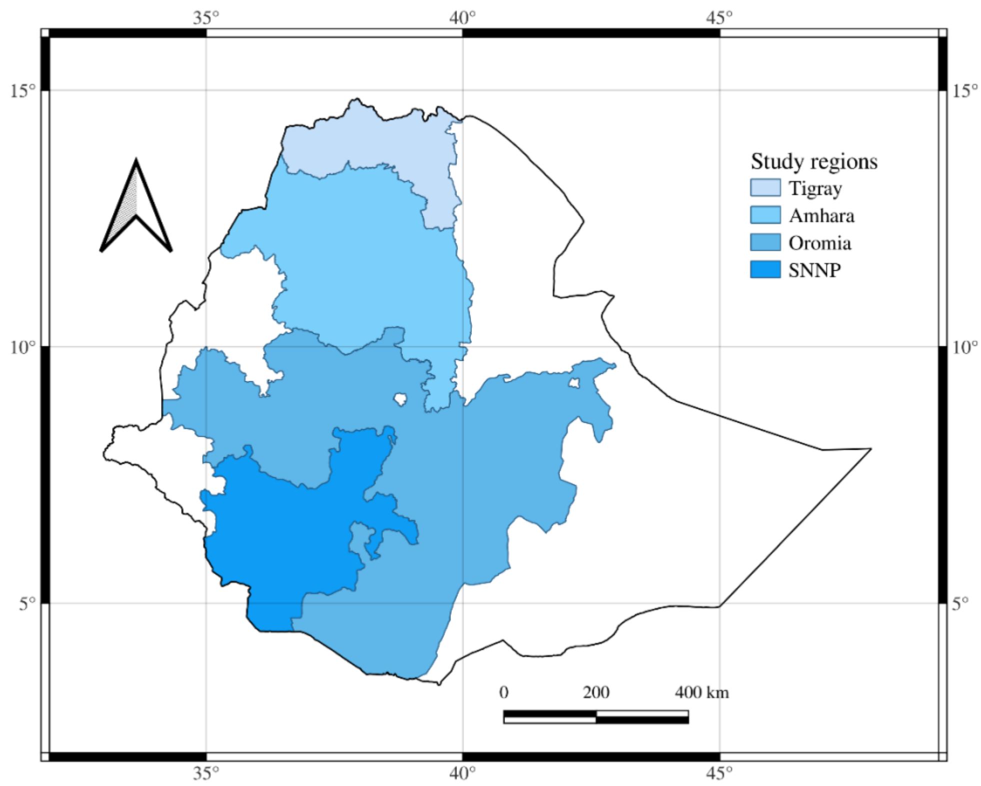

Figure 1: Map of Ethiopia and study locations.

2.2 Approach

To estimate the causal effect of accessing weather and climate services[4] on crop productivity, we employ the panel data estimation method. The baseline and end-line survey results provided two rounds of panel data surveyed within five years, tracking the same household surveyed during the baseline survey. The dependent variables consist of farm productivity (yields) for the selected major staple groups (cereals, pulses, oilseeds, and coffee), including for the four important crops grown (tef, maize, wheat, and sorghum) in the country. Farm productivity is defined as the total output of crop production in kilograms per hectare. Having access to weather and climate services,

[4] One may argue that there might be contamination bias where the 'control' groups (in our case, farmers who do not receive CIS) inadvertently receive the treatment (i.e., recipients of CIS). However, we argue that farmers that receive weather and climate services through informal ways might receive poor quality (or even distorted) information that may jeopardize their productivity.

our variable of interest, is a dummy variable that takes "1" for households that receive CIS and "0" for those who do not receive CIS.

To empirically test the hypothesis that exogenous CIS significantly affects crop yield, we use the following panel data estimation method:

$$Y_{it}=\beta_0 +\beta_1 x_{1it} +\beta_2 x_{2it}+ \beta_3 x_{3it} +\varepsilon_{it} \quad (1)$$

Where Y_{it} is household 'i's log crop production per hectare at time t. Our variable of interest (CIS) is denoted by x_1, and β_1 quantifies the impact of weather & climate services while β_2 captures the impact of other yield impacting controls, including agricultural input use such as fertilizer, improved seed, agrochemical, and total labor. β_3 captures the effect of additional household characteristics (including the gender of the household head, age, head education, total asset, and whether the household is selected as a model farmer). The last term in equation (1) is a stochastic error term that captures the remaining sources of variation in farm productivity. When appropriate, we use fixed effects, random effects, and pooled data estimation methods. In fixed effect estimation, the error term consists of two components. The first part is individual heterogeneity which is not varying over time, and the second is some random shock to the yield function that is also unobserved by the household. In the estimation of the panel data model, controlling for the unobserved effect is important. Under certain circumstances, the fixed effect transformation is applied to eliminate the fixed unobserved effect.

The regression is done in a stepwise fashion. We initially estimate equation (1) without additional controls except for access to CIS. Then, we extend the specification through a stepwise inclusion of relevant covariates.

3. Results

3.1. Household characteristics of sample respondents

Table 1 compares household characteristics over the baseline (2013) and end line (2018). The average household size is slightly bigger (5.1) in the end-line relative to the average (4.8) in the baseline. We categorized years of schooling into three levels of education, as presented in table 1. Within each category, the education variable shows the highest level of education achieved by the head of the household. The level of education is almost the same over the two rounds, with most household heads (about 64 %) with a primary level education. The share of male-headed households slightly declined from 73% in 2013 to 71% in 2018. Considerable improvement is observed in the value of the total household asset owned, which was more than triple over the 2013-2018 period. Looking at the change in land characteristics of the household over the two periods, the average farm size and the fertility of the soil have declined slightly from what it was in 2013. This result is consistent with other studies (e.g., Dorosh et al., 2018) that also showed a contraction of cultivated areas in the country. In each round, less than 50% of respondents reported engaging in soil and water conservation practices.

On the other hand, there is a significant improvement in adopting modern agricultural inputs such as fertilizers and improved seeds. While fertilizer application increased by 87%, improved seed application rose by 67% between 2013 and 2018. In contrast, the percentage occurrence of crop damage declined considerably over the five years. Probably owing to these positive changes, enhanced use of modern inputs, and improved crop management practices, yields of maize (23%) and wheat (15%) considerably increased over the 2013 and 2018 period even though tef yields have declined (by 12%) during the same period.

Table 1: Trend of household characteristics over the two-survey period

Household Characteristics	2013	2018
Household size	4.8	5.1
HHH gender(1=male)	73.0	71.0
HHH age	42.0	47.0
Education (percentage)		
Primary	64.2	64.6
Secondary	14.0	15.0
higher	1.8	1.8
Value of total asset (Birr)	916.0	3256.0
Total active labour (number)	2.4	2.5
Land characteristics		
Area(ha)	0.4	0.3
Plot distance(minutes)	11.7	16.0
Fertile soil(1=yes)	74.7	67.5
flat land(1=yes)	77.6	76.5
HH soil conservation(1=yes)	43.3	44.1
Yield and input uses		
Yield (kg/ha)		
Maize	1662.7	2050.6
Teff	805.8	712.8

Wheat	1477.5	1699.3
Input uses		
total fertilizer(kg)	93.58	174.68
Improved seed use(1=yes)	24.00	40.00
Agro-chemical(kg)	0.75	0.80
Total labor	10.71	8.29
Irrigation use(1=yes)	1.03	1.00
Crop damage variables		
Storm Wind affect crop(1=yes)	7.4	1.2
Frost affect crop(1=yes)	3.6	1.3
Waterlogging affect crop(1=yes)	5.0	0.9
Plant disease affect crop(1=yes)	4.9	0.9
Insects affect crop (1=yes)	4.8	0.5
Weed affect crop(1=yes)	18.6	1.5

Source: Authors' computation

3.2.Access to weather and climate services

Table 2 presents a descriptive summary of CIS from the end-line survey. Only 705 (18 %) of the 3,887 farming households accessed weather and climate services. Of those farmers who accessed these CIS, 73% confirmed to have understood the information they received, 45% stated that they received the services on time (e.g., well before the growing season), and 40% believed that the services they received were adequate. Of the farmers with access to CIS, 31% received daily weather forecasts, 27% received rainfall onset and cessation dates, 20% forecast of the start of the rain, 15% reported receiving ten-day forecasts, and 6% received warnings of the occurrence of flood and drought, while 16% received combinations of these services. Respondents were also asked about their most important weather and climate service type they wished to have received. Respondents gave the highest priority to information on onset and cessation dates (as reported by 31% of farmers), followed by daily forecasts (20%), forecasts of the start of rain (16%), and combinations of the different types (23%). In contrast, the occurrence of flood and drought (5%) and ten-day forecasts (5%) were cited as less preferred. As stated by farmers with access to weather and climate services, the crucial times for receiving weather and climate services were during planting (16%), agrochemical application (35%), extreme events (15%), the combination of all (34%), and other (0.3%). Table 2 also provides information on the preferred media for weather and climate services dissemination. While 63% and 19% of the farmers respectively identified radio and TV as their preferred mode of dissemination of the services, 8% and 4% of these farmers also mentioned extension agents and friends/neighbors respectively as their preferred mode of dissemination. Interestingly, only a few farmers (2%) identify mobile phones (SMS) as a good modality of dissemination. This could be due to the low literacy rate in rural Ethiopia since one needs to read SMS messages to understand the content.

Farmers identified media use (either access to media or suitable timing) and financial constraints as the two most important challenges, each mentioned by 18% of the farmers. Language of service communications was a major challenge for 8% of the respondents, while 6% reported a lack of decision-making among the challenges - more than a third (33%) of them reported no constraint to act on the information. This may be because they were not interested in using these services or perceived that the information provided to them was sufficient.

Table 2: Access, modality, and constraints to weather and climate service use (N= 705)

Access to weather and climate services	**Unit (%)**
Receive weather and climate services	
- Yes	18
Do you receive weather and climate services on time (e.g., before planting season)?	
- Yes	55
Do you understand the content of the weather and climate services you receive?	
- Yes	73
Do you think the weather and climate services you received are sufficient?	
- Yes	40
How frequently do you receive weather and climate services?	
- Daily	23
- Every other day	16
- Once per week	33
- Twice per week	24
- Other	4
What type of weather and climate services do you receive?	
- Daily forecasts	31
- Ten-day forecasts	6
- Rainfall onset and cessation	27
- Forecasts of the start of rain	20
- Occurrence of flood and drought	2
- Combination/other	16
For which activity do you need weather and climate services?	
- Planting	16
- Application of agrochemicals (e.g., fertilizer, pesticides, etc.)	35
- Extreme events (e.g., drought, flooding, etc.)	15
- Combination of all	34
- Other	0.3
Which type of weather and climate services is most important to you?	
- Daily forecasts	20

- Ten-day forecasts	5
- Rainfall onset and cessation	31
- Forecasts of the start of rain	16
- Occurrence of flood and drought	5
- Combination/other	23
Which weather and climate services dissemination media do you prefer?	
- Radio	63
- TV	19
- Mobile phone/SMS	2
- Extension agents	8
- Friends/neighbors	4
- Combination/other	4
What are the main barriers to the use of weather and climate services?	
- Media of disseminating the services	18
- Language of disseminating the services	8
- Lack of financial resources	18
- Lack of decision making	6
- Combination/other	17
- No barrier	33

Source: Authors' computation

Table 3 demonstrates a statistical test for selected variables across households with access to CIS and those without access. For the two groups of households, statistical difference is observed for almost all socio-economic factors such as gender, household size, and value of total assets owned except for education level. Households with access to CIS have a large household size, and they are endowed with relatively big active labor members (i.e., between 14-64 age group). The total asset value for a household receiving climate service is three times (i.e., Birr 5,522) than households with no access (i.e., Birr 1,819). Looking at the yield difference between the two households, the average yield of maize and wheat is significantly higher for a household that received CIS. However, there is no statistical difference between the two households in the case of tef yield. Similarly, farmers with access to weather and climate services seem to apply more fertilizer and are more likely to use improved seeds.

Table 3: Comparison of variables for HH that received climate information services (CIS) and HH that didn't receive

	No climate service received	Climate service received	Sig.
Household Characteristics			
Household size	4.8	5.8	***
Head gender(1=male)	70.0	84.7	***
Education (percentage)			
Primary	64.0	65.0	n/s
Secondary	14.0	16.6	n/s
higher	1.7	2.4	n/s
Value of total asset (Birr)	1819.0	5522.0	***
Total active labour (number)	2.4	2.9	***
Yield(kg/ha)			
Maize	1839.0	2106.0	**
Teff	765.0	695.0	*
Wheat	1541.0	1885.0	***
Land characteristics			
Area(ha)	0.4	0.3	**
Plot distance(minutes)	13.7	14.2	n/s
Fertile soil(1=yes)	71.7	64.7	***
flat land(1=yes)	77.0	74.0	n/s
HH soil conservation(1=yes)	42.0	59.8	***
Input uses			
total fertilizer(kg)	62.8	84.1	***
Improved seed(1=yes)	30.1	47.3	***
Agrochemical(kg)	1.3	1.3	n/s
Irrigation use(1=yes)	2.5	4.5	**

Source: Authors' computation. Significance tests were performed to determine whether there is a statistical difference b/n HH receiving climate info and those that didn't receive across different variables. Associations found to be statistically significant are indicated by level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$; n/s=not significant.

Figure 2 shows the effect of access to CIS on the average yield of cereal and pulses. The figure on the left displays the association between households' access to climate service and cereal yield. The effect of climate service on the yield of cereal crops is higher, as seen from the right shift of the kernel curve for the household with access to climate service. However, there is no such observed effect of receiving climate service on the yield of pulses.

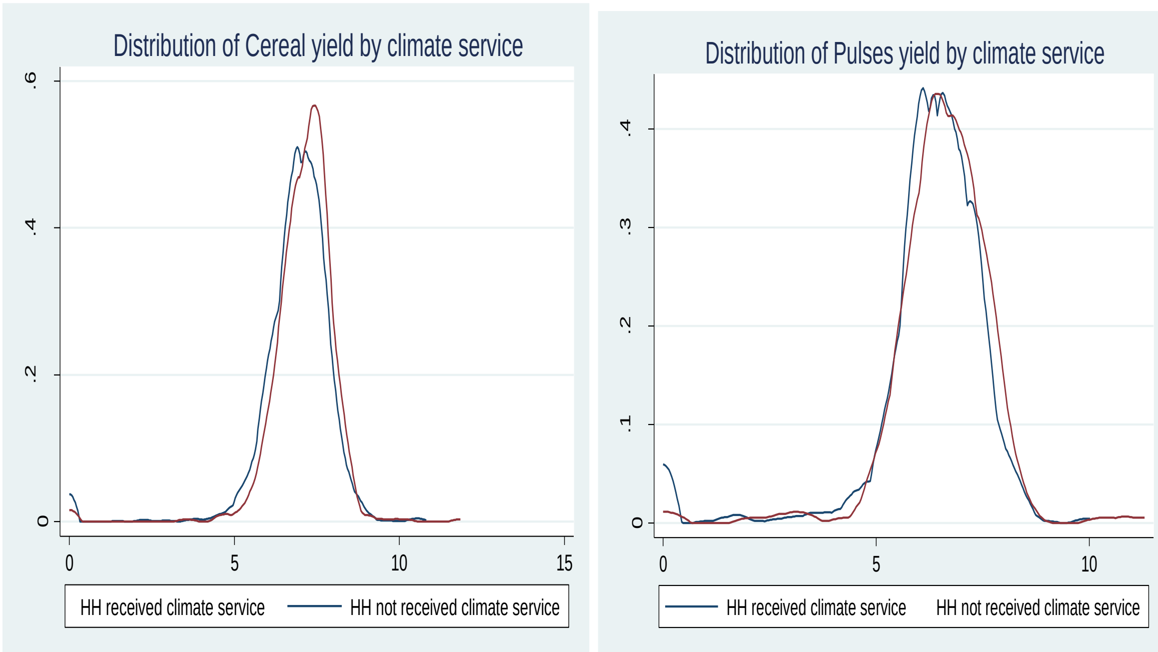

Figure 2: Effect of access to climate service on the average yield of cereal and pulses crop

3.3 Impact of weather and climate services on agricultural productivity

Table 4 presents two sets of results from panel data estimation techniques. Table 4 (a) presents determinants of crop productivity for four crop groups: cereals, pulses, oilseeds, and coffee. For each crop group, we regress the dependent variable, which is the logarithm of yield (kg/ha), against a host of controls. Access to CIS (a dummy indicating whether a given farmer received CIS or not) is included among the explanatory variables. For each crop, we test the impact of CIS under two specifications. First, we use a parsimonious specification where we only include the climate service variable. Second, we control several variables that could potentially affect crop productivity in less parsimonious regression. The model choices (fixed effects, random effects, or pooled) and justifications (i.e., statistical tests) are also indicated in the table. According to the results in table 4(a), there is no evidence that accesses to CIS lead, at least in the current settings, to higher productivity for pulses, oilseeds, and coffee. However, the results show that access to weather and climate services leads to substantially higher productivity gains for cereal crops. On average, farmers that received CIS seem to get 17% higher cereal productivity than those who did not receive CIS. The positive impacts of CIS on agricultural crop productivity are consistent with studies conducted in India, such as Singh et al. (2020), who reported the economic impacts and usefulness of agro-met advisory services for the wheat crop of Siddhartha Nagar district of Uttar Pradesh, Ramachandrappa, et al. (2018) who assessed the usefulness and impact of agromet advisory services in the eastern dry zone of Karnataka, and Vashisth et al. (2013) who examined weather-based agromet advisories for enhancing the production and income of farmers under changing climate scenario.

Interestingly, this productivity gain is considerably higher than the productivity gain pertaining to fertilizer application. The second set of results of Table 4 (4b) presents estimates for the four most important cereals: tef, maize, wheat, and sorghum[5]. Here, we also use similar dependent variables, explanatory variables, and specifications in Table 4a. Looking at the estimates presented in Table 4b, the impact of access to weather and climate services seems to vary by crop. While access to CIS seems to have little effect on the productivity of tef and sorghum, estimates show that it leads to a considerable productivity gain both for maize and wheat. Access to tailored weather and climate services is found to lead to 27% and 17% productivity gains for maize and wheat, respectively. To put this into perspective, we compared the productivity gains from access to CIS to the conventional productivity-enhancing inputs (such as the application of fertilizer). We found that gains from the application of fertilizers lead to only 8% and 12% productivity gains in maize and wheat fields, respectively.

[5] These four staple crops altogether account for 76% of overall grain production (CSA 2019).

Table 4: Impact of climate information on agricultural productivity: Panel data model estimation

(a)

Dependent variable →		**Log (Yield (kg/ha))**							
		Cereals		**Pulses**		**Oilseeds**		**Coffee**	
Explanatory variable		**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**
HH received WCS	**yes = 1**	**0.183*** **	**0.168** **	**0.278** **	**0.064**	**0.145**	**-0.176**	**0.156**	**-2.657**
Farm size	Log (ha)		-0.488***		-0.908***		-0.654***		-3.684*
Fertilizer	Log (kg/ha)		0.052***		0.057		0.006		0.080
Improved seed	Log (kg/ha)		0.010		0.041		-0.054		-0.455
Extension visit	yes = 1		0.196**		-0.004		0.191		0.291
Land indicators (soil quality, land slope, and soil conservation)		No	Yes	No	Yes	No	Yes	No	Yes
Environmental and agronomic factors (frost, insect, waterlogging, disease, birds)		No	Yes	No	Yes	No	Yes	No	Yes
Extension service (advise on land preparation, fertilizer application, planting)		No	Yes	No	Yes	No	Yes	No	Yes
HH characteristics (gender, age, education, religion, total asset, and model farmer)		No	Yes	No	Yes	No	Yes	No	Yes
Intercept		6.809***	7.092***	6.279***	2.984***	5.74***	5.95***	6.158***	5.95***
No. of observation		6071	1,392	1,694	435	519	151	534	144
F(,)/ Wald chi2		8.20***	2.18***	8.46***	2.61***	0.7	-	0.56	1.92
Hausman test (Chi2(,))		6.39***	49.96***	0.37	22.65	0.01	28.75	1.93	31.32*
BrueschPagan LM test		-	-	0	0	1.84*	0.01	2.25*	-
Preferred Model		FE	FE	Pooled OLS	Pooled OLS	RE	Pooled OLS	RE	RE

Source: *, **, *** indicate significance at 0.1, 0.05 and 0.01 significance levels; robust standard errors

(b)

Dependent variable →		Log (Yield (kg/ha))							
		Teff		Maize		Wheat		Sorghum	
Explanatory variable		**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**	**Spec. 1**	**Spec. 2**
HH received WCS	**yes = 1**	**-0.052**	**0.027**	**0.508****	**0.272****	**0.190*****	**0.167***	**0.254**	**0.241**
Farm size	Log (ha)		-1.287***		-1.577***		-0.861***		-5.09**
Fertilizer	Log (kg/ha)		0.071***		0.078***		0.121***		-0.018
Improved seed	Log (kg/ha)		0.059***		-0.040		0.046		0.076
Extension visit	yes = 1		0.211***		0.208**		0.121*		0.020
Land indicators (soil quality, land slope, and soil conservation)		No	Yes	No	Yes	No	Yes	No	Yes
Environmental and agronomic factors (frost, insect, waterlogging, disease, birds)		No	Yes	No	Yes	No	Yes	No	Yes
Extension service (advise on land preparation, fertilizer application, planting)		No	Yes	No	Yes	No	Yes	No	Yes
HH characteristics (gender, age, education, religion, total asset, and model farmer)		No	Yes	No	Yes	No	Yes	No	Yes
Intercept		6.357***	6.064***	7.095***	5.593**	7.044***	6.523***	6.701***	8.912***
No. of observation		2,508	704	3,074	2,045	519	571	641	156
F(,)/ Wald chi2		0.81	8.40***	28.03***	5.39***	11.63***	74.57***	2.40	2.61***
Hausman test (Chi2(,))		1.28	18.21	12.37***	67.70***	1.33	24.59	1.93	26.82
BrueschPagan LM test		10.46***	0	-	-	21.29***	4.47**	0	0.03
Preferred Model		RE	Pooled OLS	FE	FE	RE	RE	Pooled OLS	Pooled OLS

Source: *, **, *** indicate significance at 0.1, 0.05 and 0.01 significance levels; robust standard errors

Authors' computation is based on Feed the Future data.

4. Conclusion

This study analyzed the impact of weather and climate services on agricultural productivity in Ethiopia. Panel data models were employed to estimate the possible impacts of having access to CIS on agricultural productivity. We find that access to existing weather and climate services boosts maize and wheat productivity by about 27% and 17%, respectively. This productivity impact is comparable to or higher than the conventional yield-increasing production technologies such as fertilizer and, at times, improved seeds. The contribution of CIS to productivity affirms the importance of the existing weather and climate information products provided in Ethiopia.

The main limitation of this study is that the survey questions focused on weather information at a short lead time: daily and ten-day weather forecasts, forecasts of the start of rains, warnings of the occurrence of flood and drought. In addition, the study only considered the suite of information products that are routinely available to farmers and not the added value of improving the design of information or aspects of CIS such as last-mile communication processes, training, and decision support systems. In line with this, further analyses are needed to estimate the value to Ethiopia's smallholder farmers of increasing investment in improving seasonal climate forecasts, mainstreaming weather and climate services in Ethiopia's agricultural extension system, perhaps through the recently co-developed and endorsed NFCS and supporting farmer decision-making with advisory tools and training. To enhance access to such services, we believe it would be useful to unbundle and analyse different components of climate and weather information, including the nature of information and how it is disseminated. Further analyses are needed to estimate the value to smallholder farmers of better seasonal climate forecasts, as well as the cost effectiveness of alternative channels for delivering time-sensitive information, whether through continued reliance on radio/TV media, mainstreaming into Ethiopia's agricultural extension system, or supporting farmer decision-making with advisory tools and training.

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Disclosuser statement

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