Estimating the economic benefits of alternative options for investing in agricultural climate services in Africa: A review of methodologies

Working Paper No. 223

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Smallholder farmers in Africa are especially vulnerable to climate fluctuations and weather extremes, and are expected to suffer disproportionately from climate change. Climate services empower the poor particularly in climate-sensitive developing countries such as the ones in Africa, and allow them to reduce exposure and vulnerability of their agricultural sector to climate-related extreme events. Hence, the importance of investing in the enhancement of generating and delivery system of climate services to the resource poor farming communities of the continent provides a low regret adaptation to future climate change. This report reviews the suitability of ex-ante evaluation methods for informing funding agencies, private sectors, and other national and regional stakeholders about the benefits of alternative investment options in climate services. The review considers relevant and recent studies taking into account the agricultural sector. The review shows that economic modelling and stated preference approaches have the widest use and potential to estimate the benefits of climate services in Africa. However, comparison of the advantages and disadvantages of the methods conveys a message that there is no one type of method that fits into all different cases in estimating the benefits of climate services. Therefore, depending on particular cases, it would be necessary to use the appropriate method or combination of methods to enhance agricultural productivity, food and nutrition security, and the resilience of the resource poor vulnerable smallholder farming communities to climate variabilities and change in Africa.

Keywords

Climate services; Cost-benefit analysis; Agriculture; Climate variabilities and change; Food security; Africa.

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Contents

Acronyms

AGRHYMET	Agriculture, Hydrology, Meteorology
AUD	Australian Dollar
CE	Choice Experiment
CGE	Computable General Equilibrium
CR4D	Climate Research for Development
CSP	Climate Services Partnership
CV	Contingent Valuation
DFID	Department for International Development
DMC	Drought Monitoring Center
ENSO	El Niño–Southern Oscillation
FCFA	Franc African Financial Community
GCM	General Circulation Model
GEM	General Equilibrium Model
GFCS	Global Framework for Climate Services
ICPAC	IGAD Climate Prediction and Application Center
KSH	Kenyan Shilling
NGOs	Non-Governmental Organizations
NMS	National Meteorological Services
NMHS	National Meteorological and Hydrological Services
RCCs	Regional Climate Centers
SADC	Southern African Development Community
SARRA-H	System of Argo-climatological Regional Risk Analysis Version H
SSTA	Sea Surface Temperature Anomalies
USAID	United States Agency for International Development
WISER	Weather and Climate Information Services for Africa
WMO	World Meteorological Organization
WTP	Willingness to Pay
ZWD	Zimbabwean Dollar

Introduction

Smallholder farmers in Africa are especially vulnerable to climate fluctuations and weather extremes, and are expected to suffer disproportionately from climate change (Altieri and Koohafkan 2008, Hertel and Rosch 2010, Harvey et al. 2014, Rakotobe et al. 2016). Climate services aim to provide people and organizations with timely, tailored climate-related knowledge and information that can be used to reduce climate-related losses and enhance benefits, including the protection of lives, livelihoods, and property (Vaughan and Dessai 2014). Climate services can help societies adapt to climate variability and change through the development and provision of science-based and user-specific information relating to past, present and potential future climate, and address all sectors affected by climate at global, regional and local scales (WMO 2016). Provision of more and better climate services, for example, allows vulnerable farmers and communities to fine-tune their planting and marketing strategies, increase farm production, enhance livelihood and food security, and lower risk, and empowers disaster-risk managers to prepare more effectively for droughts and heavy precipitation (Patt et al. 2005, CARE 2014, Snow et al. 2016, WMO 2016). Studies indicate that there is substantial demand for climate services among farmers in Africa (e.g. Hansen et al. 2011), and that access to climate information influences farmers' decisions, even when resource constraints limit their options (Ngugi et al. 2011, Phillips et al. 2001, Mudombi and Nhamo 2014, Rasmussen et al. 2014, Wood et al. 2014, Bryan et al. 2009, 2013, Gebrehiwot and van der Veen 2013).

In most African regions, there are encouraging initiatives to improve the generation, delivery and use of climate information. At a continental and regional scale, these initiatives include the UN Global Framework for Climate Services (GFCS) (WMO 2011), the ClimDev-Africa program—which supports Africa's response to climate variability and change by improving the quality and availability of information and analysis to decision-makers at the regional level (UNECA 2008), the DFID-funded WISER programme that aims to enhance the resilience of African people and economic development to weather and climate-related shocks,), USAID, the African Climate Research for Development (CR4D) initiative and a network of Regional Climate Centers (RCCs) that provide online access to products and services to national meteorological services and regional users (GFCS 2009). However, at the national scale, the provision of various public sector services, including climate services, has come under increasing budgetary pressure and scrutiny due to the intense competition for scarce public funds (Anaman et al. 1995, Rogers and Tsirkunov 2013, Perrels et al. 2013). Decisions to invest scarce resources in new services or improvements to existing services are best made on the basis of evidence of the benefits that the changes are predicted to produce, relative to the costs (Rollins and Shaykewich 2003, Gunasekera and Zillman 2004, Zillman 2007, Anaman et al. 1995, Freebairn and Zillman 2002).

Effective use of often scarce financial resources in the continent for climate services in the agriculture sector, however, requires trade-offs and answers to several questions: i) What are the costs and benefits of alternative options for investing in climate services for agriculture and food security? ii) What methods can best overcome current gaps in knowledge and evidence needed to inform national and regional investments in climate services? iii) How can funders and implementing institutions best target and coordinate efforts to build capacity for climate services, considering potential synergies and overlaps? iv) How can climate services and early warning be best integrated into national climate change, and food and nutrition strategies and policies?

Ex-ante methods provide estimates of the expected benefits from planned future investments, and can be used to hierarchically identify which of several options for allocating the scarce financial resources are likely to yield the greatest benefit (Freeman III 2003, Samset and Christensen 2015). Ex-ante evaluation of planned future investments, and ex-post evaluation of services that are already operational play complementary roles in improving our understanding in the valuation of services and products (Freeman III 2003). This report reviews the suitability of ex-ante evaluation methods for informing international, regional and national funding agencies, Africa's development partners, and other private and public sector stakeholders in the continent about the costs and benefits of alternative investment options in climate services. Climate services empower the poor particularly in climate-sensitive developing countries such as the ones in Africa, and allow them to reduce exposure and vulnerability of their agricultural sector to climate-related extreme events (GFCS 2016). Hence, the importance of investing in the enhancement of generating and delivery system of climate services to the resource poor farming communities of the continent provides a low regret adaptation to future climate change, and enhances the food security and livelihood of people living in Africa (World Bank 2008, Rogers and Tsirkunov 2013, Dinku et al. 2016 Vaughan et al. 2016, Vincent et al. 2017).

A typology of climate services investment

Identifying the essential components of climate services in the agriculture sector has important implications for targeting and coordinating investment, as investing in these different components, alone or in combination, is likely to have quite different costs and benefits. Early research on the use of seasonal climate forecast information by farmers in the developing world makes it clear that benefit depends on more than the provision of credible information (Jones et al. 2000, Patt et al. 2005, Cash et al. 2006, Hansen et al. 2011). A multi-stakeholder, cross-sectorial assessment of the use of climate information in Africa concluded that the desire for climate information by development stakeholders and at the same time their inability to pay for it and inadequate supply of relevant climate information interact to constrain the use of climate information to manage risk and advance development (IRI 2006). This suggests that the development of climate services requires addressing supply-side and demand-side constraints in parallel if the benefits of climate services are to be realized and sustained. Collective understanding continues to evolve, regarding what is needed to enable farmers and other decision-makers in Africa to act effectively on climate information, and hence what components and institutions must be integrated into climate services for them to be effective. While early work on climate services in the continent emphasized "providers and end-users," the development of climate services increasingly involves a range of government agencies, boundary institutions and technical expertise that play essential roles between the production of climate information by national meteorological services (NMS) and use of information by end-users such as farmers. The range of intermediary institutions and processes tends to be greater when climate service initiatives are led by agriculture or other climate-sensitive sectors, than when led by the climate community.

There have been a few efforts to propose typologies of the components or characteristics that are essential if the society is to benefit fully from climate services in Africa. The definition proposed by the Climate Services Partnership (CSP) provides the starting point for a simple typology: "Climate services involves the production, translation, transfer, and use of climate knowledge and information in climate-informed decision-making and climate-smart policy and planning" (ICCS5 2017). Adding the institutional and governance arrangements that enable sustained co-production of services gives five target components of climate services that require attention and investment (see Table 1). Weaknesses in any of these target components for investment can constrain the use and benefit of climate services.

The need for and priority areas of investment in climate services are studied in many developing countries including countries in Africa. Results of these studies emphasize the need for investment in the area of observational network, human and institutional capacity building and service delivery system (World Bank 2008, AMCOMET 2010, Rogers and Tsirkunov 2013, Vaughan et al. 2016, Vincent et al. 2017). In addition, other crucial areas of investments include research and development (UNECA 2013), collaboration, policy and practice, information and knowledge capture (IRI 2012). Such evidences highlight the importance and strategy to prioritize investment in climate services.

Table 1. Proposed typology of targets for investment in climate services for agriculture

Component	Examples / sub-components	Key institutions involved
Production	Observations, data management, prediction.	National meteorological services and national agricultural research institutes (e.g. NMA[1], ATA[2], EIAR[3] etc.), regional climate centers (e.g. ICPAC, AGRHYMET, SADC/DMC etc.).
Translation	Crop production forecasts, pest and disease risk management and other agro-advisories.	National agricultural offices and extension services, development NGOs.
Communication	Disseminating climate services in culturally and socially acceptable ways.	Agricultural extension, development NGOs, agribusiness, media.
Use	Contingency planning and early response processes, training and education, integrating climate services with input supply or finance.	General public, media, NGOs, community leaders, Farmer Training Centers (FTC), farmers.
Governance	Multi-agency coordination, business models, monitoring and evaluation, accountability.	Funding agencies, supporting agencies, NGOs.

[1] NMA refers to the National Meteorological Agency of Ethiopia

[2] ATA refers to the Agricultural Transformation Agency of Ethiopia

[3] EIAR refers to the Ethiopian Institute of Agricultural Research

The value of climate information

According to Hilton (1981), the value of information can be defined as the: i) maximum price that a user would pay for it, ii) minimum price under market equilibrium that a provider would accept for the information, and iii) expected improvement in economic benefit of management that incorporates the new information. Methods used to estimate the value of climate information for agriculture in this review are based on either the first or third of these definitions. The public goods nature of information limits the usefulness of assessing its value based on market equilibrium process according to Hilton's second definition.

Climate information embodies two features of a public good. First, climate information is non-rivalrous. Once generated, the marginal cost of reproducing and supplying climate information to another user is very low; and the use of climate information by one user does not infringe on its usage by others. Second, climate information is non-excludable. It is very difficult and potentially expensive to exclude users from accessing climate information (Gunasekera 2002, Freebairn and Zillman 2002). The public good nature of climate information generally prevent markets from revealing its value, except in the case where highly specialized information products and services (e.g. aviation forecasts) might be sold.

Although some methods estimate the value of climate services in terms of expected improvement of economic returns from acting on the information, the potential benefits of climate services to agriculture go beyond economic returns to include social and environmental. The economic benefit from climate information for smallholder farmers comes primarily through altering management in ways that increase production or income, or reduce production costs (Tall et al. 2014, LO and Dieng 2015). Some of the social benefits include change in agricultural practices (e.g. greater mastery of cropping calendar) and better planning of farming activities (e.g. planned spending of money and better labor management) (Tall et al. 2014, LO and Dieng 2015), and enhanced food security and other livelihoods related benefits. Effective use of climate services may result in an environmental benefit as well. For example, proper timing of application of nitrogen fertilizer to reduce nitrous oxide (N_2O)—a greenhouse gas with the highest global warming potential emissions from crop fields (Signor et al. 2013), and balanced application of fertilizer and other agro-chemicals reduces environmental pollution (Hautala et al. 2008, Lazo et al. 2009, Selvaraju et al. 2011).

Available methods to estimate benefits of climate services

The approaches available to quantitatively estimate the benefits of climate information can be classified as economic modelling, stated preference, avoided loss and benefit transfer (Freebairn and Zillman 2002, World Bank 2008, Clements et al. 2013, WMO 2015). Their basis, related methods, and main strengths and limitations are summarized in Table 2.

Table 2. Overview of approaches to estimate costs and benefits of climate information services for agriculture in Africa

Approach	Basis[a]	Method	Strengths	Limitations
Economic modelling	Improved economic benefit	Bio-economic modelling	Can sample many years of climate information and weather observations. Flexible model specification.	Realism limited by model ability to capture decisions and economic impacts. Ignores market impacts of adoption at scale.
		Economic equilibrium modelling	Captures market impacts of adoption of climate services at scale.	Realism limited by model ability to capture decisions and economic impacts.
		Game theory	Captures competition or coordination among decision-makers.	Significant data, time and expertise requirement.
Stated preference	Maximum price a user would pay	Contingent valuation	Seeks the value of goods and services from a hypothetically constructed market.	Bias from limited experience and understanding of planned information products.
		Choice experiments	Elicit individuals' preference for potential good or service by describing the good or service in terms of its attributes.	Sensitivity of results to survey design.
Avoided loss	Improved economic benefit		Straightforward when action thresholds, frequencies and losses are known.	Only considers downside risk, not opportunity under favorable climatic conditions.
Benefit transfer	Extrapolation of estimates based on other approaches		Minimal data, cost and time requirements.	Low and uncertain realism, especially when transferring results from a very different environment.

[a]Based on the three definitions of value of information in Hilton (1981).

Economic modelling

The value of climate information in the agriculture sector, defined as the expected increase in economic benefit resulting from the use of the new information by stakeholders or beneficiaries (e.g. African farmers), can be estimated using economic modelling tools. The economic modelling methods that are used to estimate the values of climate information services include bio-economic modelling, equilibrium modelling and game theory (World Bank 2008, Clements et al. 2013, WMO 2015). Regardless of the method, the expected societal economic returns or benefits of decisions with and without the new climate information are estimated by sampling available years of historical climate information.

Bio-economic modelling applied to climate services in agriculture assumes that decision makers have some level of prior climate knowledge (both indigenous and scientific data-based), and that if updated or better climate information is provided, the decision maker (in this case the famer) will use the additional information to make optimal choices. The value of climate information is then equal to the increased payoff when updated information is used, relative to when prior knowledge is used (Rubas et al. 2006). Modelling based on bio-economic modelling approach focuses on a single decision maker, without taking into account what other decision makers are doing, or the impact that a large number of decision makers (in the context of this paper smallholder farmers) may have on supply and demand (Rubas et al. 2006, Peterson 2009, Clements et al. 2013).

Economic equilibrium modelling treats the economy as a collection of economic agents who make supply and demand decisions in order to further their own interests (Bryant 2010). Economic equilibrium modelling in agriculture estimates benefits to society in terms of consumer and producer surplus, in response to changes in supply and demand, and resulting price effects, associated with decisions based on climate information (WMO 2015). As the number of producers using climate forecasts increases, their decisions have increasing influence on total agricultural production, which can influence supply-demand equilibrium for other commodities and services (Rubas et al. 2006). General equilibrium modelling (GEM) attempts to capture these effects across the entire economy, while partial equilibrium modelling confines the analysis to a specific sector (e.g. agricultural sector) or sub-sector. These methods are data intensive, which has so far limited their widespread application to climate services (WMO 2015). But they are applied more widely to estimate the expected aggregate benefits of major agricultural development investments and widespread adoption of agricultural production technologies (Andre et al. 2010).

Game theory is a mathematical technique for analyzing situations in which two or more individuals make decision that will influence one another's welfare (Myerson 1997). In the case of countries whose farmers either use or do not use climate forecasts, payoffs (i.e., increases in expected producer surplus) are expected to vary based on which countries adopted the forecasts, because of economic linkages between countries (Rubas et al. 2006). Game theory has the advantage of portraying how conflict and cooperation between decision makers impact their payoffs. But this method is not widely applied in the agriculture sector as a whole and specifically in Africa partly due to significant data, time and expertise required. The only published application of this method to climate services for agriculture is by Rubas et al. (2006), who showed that cooperation between countries can increase worldwide economic gain from climate forecasts.

Stated preference

The stated preference approach estimates the value of climate services based on the maximum price that a user would pay for the information, or "willingness to pay" (WTP). It can be used to estimate a monetary value for a service that may have no market, limited market or incomplete market (Champ et al. 2003, Rollins and Shaykewich 2003), by constructing a hypothetical market (Bateman et al. 2002, TEEB 2010). The most frequently used stated preference methods applied to weather and climate services, including the agriculture sector are contingent valuation (CV) and choice experiments (CE) (World Bank 2008, Frei 2010, Clements et al. 2013, WMO 2015). The CV method uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for a specified improvement (Mitchell and Carson 1989). It is a relatively simple method for estimating the economic value households attach to weather and climate information (e.g. Anaman and Lellyett 1996, Lazo and Chestnut 2002, World Bank 2008, Rollins and Shaykewich 2003). The main limitations of this method are the potential for response biases (Tietenberg 1996). Potential sources of these biases include: i) strategic bias where respondents provide biased answers to influence a particular outcome, ii) starting point bias that arises when survey instrument provides predetermined range of choices for answering their values, iii) hypothetical bias that occurs when respondents do not take the study seriously, iv) sampling bias which is a result of improper sampling design and execution, and v) information bias which happens when respondents are forced to value certain goods or services of which they have little or no experience (Ahmed and Gotoh 2006, Haab and McConnel 2002, Fujiwara and Campbell 2011). Pate and Loomis (1997) argue that CV values are contingent upon the levels of information provided by the survey in addition to the amount of information respondents bring to the survey. Attempts to reduce these biases makes the study expensive and time consuming (Ahmed and Gotoh 2006).

In the CE method, individuals' WTP for climate information services in agriculture is estimated by presenting respondents with two or more alternatives of, e.g., climate information services, with a number of attributes, with one of the attributes being monetary value. Respondents are then asked to choose among the different alternatives described in terms of their attributes and the level taken by the attributes. By repeating such choices, with varied attribute levels, the researcher can examine respondents' preferences for the attributes and prices associated with their preferred options, and infer their WTP (Hanley et al. 2001), in this case for climate information and services. The CE method is an improvement over the CV method since the former allows estimation of the value of goods and services based on their attributes taking monetary value as one of the attributes (Hanley et al. 2001, Nguyen et al. 2013). Sensitivity of results to survey design, choice complexity, and time and data intensity are some of the disadvantages of the method (Haab and McConnel 2002, Fujiwara and Campbell 2011) and its potential for sector-wide application for African agriculture.

Avoided loss

The avoided loss method estimates the benefits in the agriculture sector based on actions in response to climate information that reduce e.g., crop or livestock losses from extreme climate events (WMO 2015). This method tends to be less data- and time-intensive than economic modelling or stated preference approaches, and easy to implement both in of ex-ante and ex-post analysis. While avoided loss can be appropriate for interventions to reduce downside risk, such as disaster response by humanitarian organizations, it does not capture the use of climate information to improve production or net income in this case of African farmers over the normal range of climate variability, and therefore does not give a complete estimate of the benefits from acting on climate information (WMO 2015).

Benefit transfer

Benefit transfer involves transferring value estimates from a "study site" to a "policy site", where sites can vary across geographic space and/or time (Bergstrom and De Civita 1999). It is used primarily when time or monetary constraints preclude the conduct of an original study to provide a required cost-benefit estimate (WMO 2015). A benefit transfer in the agriculture sector occurs when value, analyzed using one of the other methods described in this report, is used as an estimate of value in a different location or application. An example is estimating the benefit of providing early warning system in developing countries based on a study of benefits for similar services in developed countries (e.g. Hallegatte 2012). This method is simple and inexpensive to apply, and could be appropriate for African countries. The main weakness of this method is that it is expected to have high generalization error resulting from the influence of differences between the study site and the policy site), and therefore low and uncertain realism (TEEB 2010).

Review of climate services valuation studies

Many studies have examined the benefits of climate information services, applying different estimation methodologies in order to guide funding agencies and policy makers. This review aims to understand the various methodologies used in estimating the benefits of investing in these services for the agriculture sector in Africa. The review considers relevant and recent studies that used economic modelling approach, stated preference approach, avoided loss method and benefit transfer technique, taking into account the continent's agricultural sector.

Economic modelling of climate information for African agriculture

Using crop simulation modelling with a decision model, Meza and Wilks (2004) estimated that the value of using perfect forecasts of sea surface temperature anomalies (SSTA) in the Equatorial Pacific—a predictor of seasonal rainfall fluctuations—for potato fertilization management in South America (Chile) is in the range of USD 6 to 28[4] per hectare.

[4] All USD equivalents are adjusted for inflation to 2017.

Thornton et al. (2004) modelled livestock production systems in the semi-arid zone of South Africa using Savanna ecosystems model to estimate the economic value of climate forecast. The result suggested that there are substantial benefits to be gained from using the forecasts in Southern Africa. For example, a farmer can cash in part of the herd even when prices are relatively low but that ecologically, herd numbers can recover adequately in subsequent seasons so as not to decrease long-term profits.

Hansen et al. (2009) used a crop simulation model and expected profit maximization to examine the potential value of seasonal rainfall forecasts, based on downscaling output of a general circulation model (GCM), for maize management in Kenya in East Africa. The value of seasonal forecasts, based on a GCM simulated with observed sea surface temperatures, ranged from Kenyan Shilling (KSh.) 734 – 3277 (USD 11 – 51) or 2 – 24% of average gross margin without the forecast, depending on location and how household labor was accounted for in East Africa. Sultan et al. (2010) used bio-economic modelling to estimate the potential economic benefits of seasonal forecasts for farmers in Senegal in West Africa. In this study, forecasts and management strategies were expressed in terms of dry, normal and wet season categories. They found that forecasting a dryer than average rainy season would be the most useful to the farmers in West Africa if they interpret forecasts as deterministic. Since forecasts are imperfect, predicting a wetter than average rainy season exposes farmers in the region to a high risk of failure by favoring crops that are highly vulnerable to drought. According to their result, the economic value of a dry forecast in West Africa is very high with an increase of income of up to 80% with respect to the control strategy in case of a perfect forecast.

Roudier et al. (2016) examined climate information that are most suitable to millet growers in Niger in West Africa, by calculating the respective benefits of 10-days forecast, seasonal forecasts and their combination. The study used an ex-ante approach which is based on the System of Argo-climatological Regional Risk Analysis Version H (SARRA-H) crop model coupled with an economic model that simulates the choice of cropping strategies. Their findings indicate that 10-days forecasts alone or a combination of 10-days and seasonal forecasts could be quite beneficial for all types of farmers. The study also noted that in cases where seasonal forecasts are not beneficial, farmers with access to credit and larger arable land in the region can still benefit from forecasts.

General equilibrium models have not commonly been used in agriculture to value the benefit of climate services due to their complexity and extensive data requirements (Clements et al. 2013). There are only a few studies that used GEM to analyze the economy-wide value of climate services in the sector. Anaman and Lellyett (1996) estimated the benefits of an enhanced weather information service for the cotton industry in Australia using the change in aggregate gross producer benefits due to reduction of unit costs of production from use of enhanced weather information service. Their result indicated that the annual aggregate gross benefit from cotton production was AUD 397,150 (USD 454,173.9) and the benefit cost ratio based on the estimated average 1% cost reduction was 12.6.

In Mexico, Adams et al. (2003) analyzed the value of El Niño–Southern Oscillation (ENSO) forecast in South America to assess the economic consequences of climate arising from various ENSO phases. They modelled estimates of regional crop yield sensitivity for key crops using a crop biophysical simulator in Mexican agricultural setting. Their findings showed benefits of an ENSO early warning system for Mexico of approximately USD 13 million annually, based on a 51-year time period of ENSO frequencies and when a forecast skill of 70% is assumed. Similarly, Rodrigues et al. (2016) adopted a computable general equilibrium (CGE) and process-based crop models to estimate the potential economy-wide value of national seasonal forecast systems in several Eastern (Kenya and Tanzania) and Southern (Malawi, Mozambique and Zambia) African countries. Their findings indicate that a timely and accurate forecast adopted by all farmers generates average regional income gains of USD 115 million per year, with much higher gains during extreme climate events. The study also found that the forecast value falls when forecast skill and farm coverage decline in both regions.

Game theory is not a widely used method to estimate the economic value of climate services in the agricultural sector mostly due to its huge data and knowledge requirement to design the game and calculate the payoffs (Rubas et al. 2006). The only application of the method in relation to climate services in the agricultural sector was by Rubas et al. (2008) who used international wheat trade model to develop a three-player game between USA, Canada and Australia. Their result suggested that cooperation between countries could increase worldwide economic gains from climate forecast use.

Stated preference

Using contingent valuation, Makaudze (2005) found that smallholder farmers in Southern Africa (Zimbabwe) were willing to pay Zimbabwean Dollar (ZWD) 2,427–4,676 (USD 3.94–7.60) annually (averages across eight districts) for improved seasonal forecast, estimated using a single-bound model[5], or ZWD 2,532–4,225 (USD 4.11–6.87) estimated using a more efficient double-bound model. Ouédraogo et al. (2015) found that cowpea and sesame farmers in West Africa (Burkina Faso) were willing to pay an average of Franc African Financial Community (FCFA)[6] 7404 (USD 15.36) annually for seasonal forecasts, FCFA 3,441 (USD 7.14) for daily weather information, FCFA 1,776 (USD 3.68) for decadal (i.e. 10-daily) weather information, and FCFA 2,884 (USD 5.98) for agrometeorological advisories. Rao et al. (2015) implemented a randomized control trial, with about 120 farmers in Makueni District, Kenya and sampled from 12 villages randomly assigned to treatments, to test the effectiveness of two different seasonal forecast communication strategies (forecast-based management advisories, training to understand as well as use downscaled probabilistic forecasts) alone and in combination. Willingness to pay for seasonal forecasts ranged KSH 125 (USD 1.93) annually for the control group, to KSH 368 (USD 4.73) for farmers exposed to both communication methods in this East African country.

Rollins and Shaykewich (2003) employed the CV method to estimate the benefit generated by an automated telephone-answering device that provides weather forecast information to users in North America (Canada). The study considered seven commercial sectors that use the information in the Toronto area of Ontario, Canada; with one of the sectors being agriculture. The study shows that the average value per call varied by sector, ranging from USD 2.9 for agricultural users to USD 0.8 per call for institutional users, with an overall mean of USD 1.6 per call.

In a recent application of the CE method, Lechthaler and Vinogradova (2016) analyzed the value of climate services to coffee producers in Peru: for an average household, the region, and the entire country. Annual WTP estimates ranged from USD 21.1 to 21.5 per hectare, and

[5] In the single-bound model the respondent is only required to answer YES or NO when asked if she/he is willing to pay a given amount for the public good, whereas in the double-bound model the first question is followed by another specifying a lower amount, if the answer to the first question was negative, and higher otherwise (Bateman et al. 2002).

[6] Currency in eight independent states in West Africa.

USD 8.3–8.4 million for the entire country. WTP for enhanced climate services was related to the information accuracy and spatial resolution in this South American country.

Avoided loss

Several studies have estimated avoided loss associated with the use of climate information services, however, few studies considered the agricultural sector in the estimation (WMO 2015) especially in Africa. The World Bank (2008), for example, conducted a series of studies to examine the avoided loss associated with large scale modernization of national meteorological and hydrological services (NMHS) in 11 European and Central Asian countries. These studies compared benefit of modernization expressed as additional prevented loss from unfavorable weather to the costs associated with modernizing the NMHS and implementing preventative measures. However, since the benefit was calculated for a number of sectors in aggregation including the agricultural sector, the benefit for the agricultural sector could not be presented separately.

Benefit transfer

A limited number of published studies have used the benefit transfer method to estimate the value of climate services in the agricultural sector (Clements et al. 2013). Despite its simplicity in application, this method is prone to high and unknown measurement and generalization error (TEEB 2010). One notable study that adopted benefit transfer method, however, was Frei (2010). This study successfully employed the benefit transfer method for a European agriculture sector and extrapolated value estimates from the literature to estimate the economic benefit of meteorological services at USD 47 million in Switzerland.

Conclusion

There are encouraging initiatives underway to improve the contribution of climate services to enhance agricultural production, food security and rural livelihoods in Africa. Identifying and estimating the costs and benefits of these climate services is vital for convincing policymakers, and public and private funding agencies that these services are a worthwhile investment, and guiding them when adjustments are needed in how those investments are used in the continent. Although the body of evidence about the economic benefits of climate services for the agriculture sector in a form that could guide investment is still rather weak, all the methods identified in this review can play a role in providing this information.

The review shows that economic modelling and stated preference approaches have the widest use in agriculture, and widest potential to answer the questions that are important to climate services investors in Africa. Economic modelling has so far been used more for understanding and insights about the scope for using climate information (primarily weather and seasonal forecasts) for agricultural management decisions than for providing realistic estimates of value of particular climate services in the continent. However, available bio-economic modelling tools have the flexibility to provide more realism, if they incorporate farmer data and input. Accounting for uncertainties in available or planned climate information products, and modelling how information influences African farmers' management decisions realistically, remain challenging. When estimating the expected economy-wide benefits of widespread adoption of a range of agricultural production technologies and development interventions in Africa, economic equilibrium modelling is an established tool for serving the purpose. With attention to realistically capturing how farmers would use climate information in the continent, it is a promising tool for estimating the potential benefits of investing in agricultural climate services.

Stated preference is a reasonably simple and cost-effective approach for estimating the subjective value that individuals place on existing climate services. The two main methods under this approach are the CV and the CE. With CV, the value of climate services among individuals can be identified by directly asking individuals the amount they are willing to pay for these services. For the CE method, willingness to pay values can be derived by giving individuals the chance to trade-off between different attributes of climate services including a monetary value. Unbiased estimates of WTP represent a lower limit of value, and should generally be below the expected economic benefit of using the service. Decision makers cannot be expected to accurately estimate the value of improvements, in the form of complex information products or services that they do not have substantial experience using.

When estimation of the benefits of climate services in the agriculture sector is conducted under a limited time and resources environment such as in Africa, the benefit transfer method could be used to transfer value from one geographical location to the other. However, the value of climate services is highly dependent on agroecological and socioeconomic context, and the benefit transfer method can't be expected to provide a reliable basis for estimating return on investment for the sector. In policy uses where the demand for accuracy is high, one should be careful in using benefit transfer since the uncertainty in spatial and temporal benefit transfer could be quite large.

The avoided loss approach is a good fit for the contribution of early warning information to disaster risk management, including interventions designed to protect farmer and pastoralist livelihoods to frequent climate variabilities and extremes and in the face of climate-driven food crises particularly in East Africa. But it is not suitable for routine agricultural management under the current infrastructure, social and capacity circumstances for the continent.

Comparison made among the various methods for estimating the economic benefits of alternative options for investing in agricultural climate services in Africa conveys a message that there is no one type of method or technique that fits into all different cases in estimating the benefits of climate information services for the continent. Depending on particular cases, it would be necessary to use the appropriate method or combination of methods. This may require an interdisciplinary approach combining data and models. In this review, there are a couple of instances pointing towards such applications. Studies that used bio-economic model, for example, incorporate crop growth simulation models to identify optimal decisions under alternative climate scenarios. Similarly, in the case of GEM, since this model is complex with an extensive data requirement, studies that estimated the benefit of seasonal climate forecast for the agricultural sector used crop growth simulation models together with bio-economic models to derive producers' production responses from forecast use.

There are many sources of uncertainties that may arise in the estimation of the benefit of climate services. Uncertainties relate to lack of knowledge about the true value of key parameters both in the present and future. For example, it is challenging to determine beforehand how individuals will respond to weather and climate forecasts in any given year. Hence, one way to account for uncertainty in the estimation of benefit would be the use of monitoring and evaluation, in addition, flexibility to make adjustments during implementation could also be considered an option.

This report reviewed cases from Australia, Europe and North America, however, and it seems unlikely that analyses of the benefits of climate services in the developed economies would be reasonable proxies for the benefits expected under the smallholder farming systems of Africa, due to the large differences in institutional capacity, the nature and value of agricultural systems (both favoring the developed world), and the inherent predictability of seasonal climate fluctuations (generally favoring the lower latitudes). Results of analyses conducted within African countries, using the other methods reviewed, might provide more reasonable estimates for neighboring countries with similar climate, agricultural systems and institutional capacity.

All studies reviewed emphasize the economic benefit derived from climate services to the agricultural sector, and none of the studies considered the environmental and social benefits of these services to the sector. To get a broader view of the benefit of these services, the estimation may need to consider the environmental and social benefits to the sector as well. Finally, all the cases reviewed support the generalization that climate information services are beneficial to the agricultural sector in Africa.

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