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Info Note

Evidence- and risk-based planning for food security under climate change

Results of a modeling approach for climate-smart agriculture programming

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Key messages

- Planning robust climate-smart development programs can be done today with existing information.
- We propose a risk-household-option modeling approach to address household food security under climate change in Africa.
- Through a case study in Niger, we demonstrate that prioritizing CSA is possible by taking into account livelihood status, risks, and potential effects of CSA practices.

Food Security and Climate Change in Africa

Although substantial gains have been made in reducing hunger in recent decades, more than 220 million people in sub-Saharan Africa are still undernourished. At the same time, climate change threatens agricultural productivity via increases in the frequency and severity of droughts, erratic rainfall, increases and shifts in pests and diseases, and changes in suitability of staple crops. Climate-smart agriculture (CSA)—farming systems that increase productivity, improve farmers' adaptive capacity and mitigate climate change where possible—has been put forward as a solution to the food and climate challenges Africa faces (Figure 1). Over the past two years, both political and non-state actors have adopted the CSA concept and have mobilized toward action on CSA in Africa.

So, what will it take to turn this momentum into a movement? Currently, complexity and uncertainty around CSA stand in the way of efficient and effective action. Complexity in CSA stems from the existence of the diverse (1) interventions (ranging from field level management practices to national and regional policies), (2) farming systems and households (from pastoralists to market-oriented smallholders), (3) potential outcomes of success (ranging from increased soil carbon to maternal dietary diversity). Uncertainty in CSA, on the other hand, is the consequence of a lack of information and data about the risks farming families face, and the efficacy of any specific CSA intervention in a given location. Despite these obstacles, policies and planning are moving forward, fast. The risk, however, is that without the appropriate information, agricultural development projects and policies may not necessarily be climate-smart.

Approaches that integrate information on households, climate risks, and CSA options are needed to support decision makers in developing more efficient and more relevant development programming. Here, we describe the results of a workshop to design an integrated risk-household-option (RHO) modeling system that relies on

Figure 1. Farmers installing zai pits in Fakara, Niger, one of the CCAFS climate smart villages. Zai pits, or planting cereal crops in small basins filled with compost or manure (a CSA practice), can double yields of millet and sorghum in degraded drylands. Photo credit: P. Savadogo (ICRAF).

currently available information to deliver key messages on potential impacts of field based interventions to policy and program developers. First, we describe the components of the approach and why they are necessary, and then we apply this approach to Niger as an example of the power and potential of evidence-based CSA targeting.

Towards an integrated modeling system for CSA

CSA aims to improve household food security in the face of climate change. Thus, effective CSA *options* need to target *risks* to the *household activities* that sustain smallholder farmers. Here we describe a three-step approach to build a robust portfolio of evidence-based response options that can be implemented with currently available data (Figure 2).

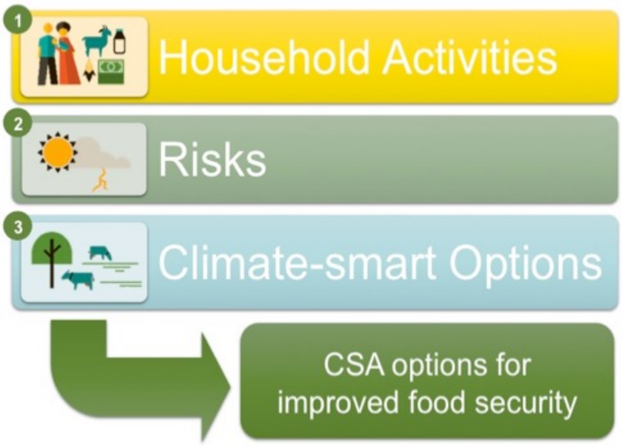

Figure 2. Steps in the Risks-Households-Options (RHO) integrated modeling system.

1. Household Activities: To achieve food security, farming households employ many different livelihood strategies and activities. Some families source all of their food supply directly from crops or livestock that they manage, while others rely heavily on income generated from the sale of surplus food crops, cash crops, or on off-farm income sources. Variation in livelihood strategies occurs both across agro-ecological zones and also among households within a given zone. Our approach takes advantage of existing household survey datasets from a variety of projects (AFRINT, CCAFS ImpactLite, CIALCA, CORAF-AUSAID, N2Africa, SIMLESA, World Bank LSMS), which together characterize more than 13,000 households across 17 countries in Africa (Frelat *et al*. 2015). We use these large datasets to characterize on-farm crop yields, to determine the relative contributions of different activities to food availability across agro-ecologies, as well as to compute an overall ratio of available to needed food.

2. Risks: Families are differentially exposed to risks because of variation in livelihood strategies. This is because different crops and livestock vary in their susceptibility to changes in weather patterns, pests and diseases, and other climate-related risks. Changes in household food availability due to risks are, to a large extent, mediated by crop and livestock productivity. A range of modeling tools including process-based, statistical, and machine learning models, allows us to model crop yield responses to weather and climate (e.g. Arslan *et al*. 2015). By quantifying both the frequency and intensity of different climate-related events (e.g. drought and/or heat spells) under current and future climates, we are able to assess the importance of these risks across farming households.

3. Climate-smart agriculture options: With an understanding of household characteristics and risk exposure levels, the next step is to determine which CSA practices fit best the different contexts. CSA practices vary in their suitability for farm level activities and agro-ecological zones, in their impact on productivity, resilience, and mitigation, as well as in their ability to address particular risks to smallholder livelihoods. The CSA Compendium (Rosenstock *et al*. 2015) is a database of more than 100,000 comparisons of CSA to baseline practices gleaned from a systematic review of more than 1,100 peer-reviewed studies on more than 70 CSA practices and 55 different outcome indicators in Africa. The CSA Compendium allows us to explore, on the basis of tangible multi-site and/or multi-year experimental evidence, the potential impact that a given practice has on indicators such as productivity, diversity, or carbon stocks. We then integrate these potential effects into the household and risk characterization, and thus are able to evaluate how CSA practices improve food security and mediate climate change impacts in a specific farming context across a broad spectrum of household livelihood strategies.

Targeting CSA interventions in Niger

Having presented our analysis framework and discussed the usefulness of model-based approaches for targeting CSA investments, the following provides an example of this approach for Niger. In Niger, agriculture contributes to ~40% of the total gross domestic product (GDP). Despite its importance, most of Niger's agricultural production occurs in low-input, subsistence farming systems that are continuously exposed to high levels of climate variability, pest and disease outbreaks, and declining soil fertility conditions. High exposure to risks and low adaptive capacity ultimately result in high levels of poverty, food insecurity, and malnutrition. Enhancing the productivity of farming in Niger while adapting to climate change is thus critical.

We used household-level survey data from the World Bank's Living Standards Measurement Survey (LSMS) database to characterize livelihood systems for households in the three major agro-ecological zones of Niger. At the national scale, 77% of farmer households are food insecure. However, our analysis reveals important region-specific priorities: the central Sahelian zone, reliant mostly on subsistence crop farming, shows the largest proportion of food insecure farmers (80%), whereas the northern Sahel-Saharan zone, mostly reliant on livestock, shows the least proportion of food insecure farmers (55%) (Figure 3, top). We also find that most food insecure households rely on growing millet and/or keeping sheep or goats for their food and income, whereas the most food secure households tend to grow a wider variety of crops (including legumes and vegetables) and livestock (including cattle and camels). Whilst the actual proportions of food insecure farmers could be lower owing to including only agricultural activities (i.e. without including off-farm income), the analyses clearly show significant opportunities for agricultural interventions to enhance food security.

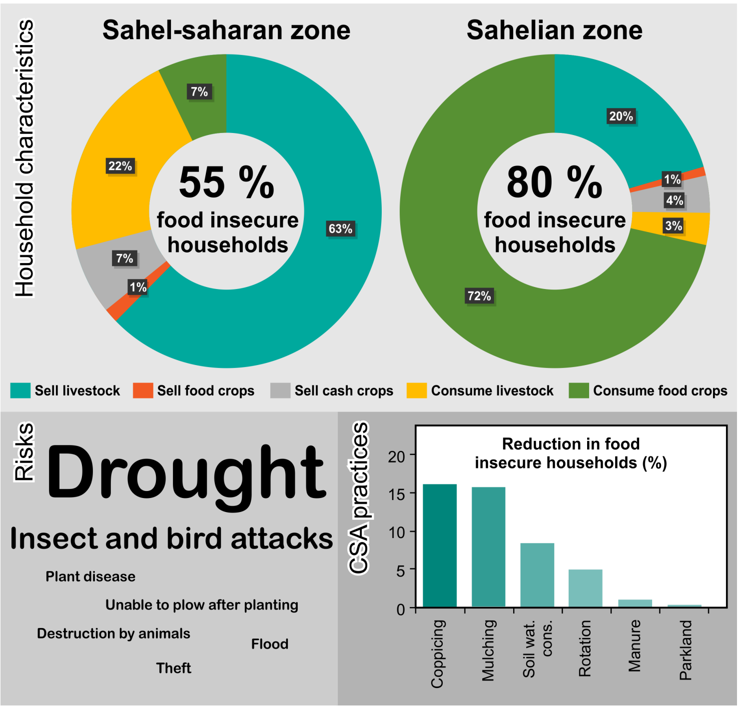

Figure 3. RHO model outputs on household food availability in Niger in two agro-ecological zones. Text size for different risks is scaled by the frequency at which each risk occurs across households. The small text in the risks panel is all below 10% frequency.

Drought is the major climate-related risk for farmers in Niger. Around 90% of the households' crop fields in the LSMS survey in 2011 had some degree of harvest loss, and from these some 65% were associated with drought (Fig. 3, bottom-left). Average loss to drought was 78%. Model results suggest early season drought is frequently associated with failure of crop plants to emerge, replanting, and increased labor burden. Severe drought stress during flowering and grain filling can severely constrain the crop's ability to develop or fill grains, accelerate leaf senescence and maturity, thus severely lowering yields. Moreover, low soil nitrogen and organic matter contents and limited use of nitrogen inputs further enhance drought impacts. Impairment of livestock production can also occur as an effect of drought, although livestock-based systems tend to be more resilient to drought. Importantly, while IPCC precipitation projections indicate likely increases in monsoon precipitation in the region late in the 21st century, addressing drought impacts on crop and livestock production will continue to be a priority in the immediate term. This risk analysis coupled with the household characterization suggests that CSA planning and implementation in Niger will ultimately require addressing drought resilience for millet and sheep/goat farming in the near term.

What CSA practices have positive impact on productivity and improve resilience to drought shocks? Here, we provide an example for grain crops. Using the *CSA Compendium* in conjunction with the household-level database, we find that significant reductions in the proportion of food insecure households are possible with CSA. Tree coppicing and mulching both reduce the proportion of food insecure households by roughly ~15%, whereas soil water conservation strategies (zai pits, water harvesting) reduce this proportion by ~10% (Fig. 3, bottom-right). While these food security impact estimates are all mediated through productivity changes in crops (millet, maize, sorghum), these three strategies also improve soil water holding capacity, and thus also help buffering against drought-induced food shocks (resilience). Furthermore, mulching presents mitigation co-benefits, by preserving soil carbon stocks.

For Niger, therefore, this preliminary analysis suggests priority investments need to address food insecurity with particular focus on cereal-based households across the Sahelian zone. Strategies that address drought risk exposure and increase productivity such as coppicing, mulching, zai pits, and water harvesting, will be key for CSA planning for farm-level interventions in the country.

Conclusions and policy implications

In the face of a rapidly growing population, dietary shifts, and high levels of poverty and vulnerability, CSA has been put forward as a solution for Africa. While the need for policies that address the multiple dimensions of climate change are clear, evidence of what works where and why is generally lacking. The modeling system we describe here uses currently available large datasets to address these questions. We demonstrate the utility of the approach to tailor CSA to household risks with a case study in Niger, highlighting the most promising opportunities and expected changes. CSA planning is moving along rapidly across Africa. Mainstreaming evidence-based approaches like the one shown here that can deliver information today will be critical to achieve more efficient and more relevant development programming across Africa.

Further Reading

- Arslan, A., *et al*. 2015. Climate Smart Agriculture? Assessing the Adaptation Implications in Zambia. *J. Agr. Econ.* 66(3): 753-780.
- Frelat *et al*. In Press. What drives household food availability in sub-Saharan Africa? Evidence using big data from small farms. *PNAS*.
- Ramirez-Villegas, J. and P. Thornton. 2015. Climate change impacts on African crop production. CCAFS Working Paper no. 119. CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS).
- Rosenstock, T.S., *et al*. 2016. What is the scientific basis for climate-smart agriculture? CCAFS Info Note.
- Rosenstock, T.S., *et al*. 2015. The scientific basis of climate-smart agriculture: A systematic review protocol. CCAFS Working Paper no. 138. CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS).

This series of briefs reports on the lessons learned and opportunities derived from the Partnerships for Scaling Climate Smart Agriculture (P4S) project, led by the World Agroforestry Center (ICRAF) and the International Center for Tropical Agriculture (CIAT). P4S engages stakeholders across Africa to roll out CSA-Plan: a guide for planning and implementation of CSA. CSA-Plan consists of four steps: (1) situation analysis, (2) targeting and prioritizing, (3) program support, and (4) monitoring, evaluation and learning. The integrated Risks-Households-Options (RHO) modeling system presented in this brief is associated with steps (1) and (2) of CSA-Plan. RHO aims to identify what CSA practices have the greatest potential for climate-adapted and low emissions agricultural development.

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