Modernizing Extension and Advisory Services

ADAPTATION UNDER THE "NEW NORMAL" OF CLIMATE CHANGE: THE FUTURE OF AGRICULTURAL EXTENSION AND ADVISORY SERVICES

By Brent M. Simpson and C. Gaye Burpee

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Note from the Editors

The Modernizing Extension and Advisory Services (MEAS) Discussion Paper series is designed to further the comparative analysis and learning from international extension efforts. The papers contain a review of extension and advisory service best practices drawn from the global body of experience in successfully reaching resource-limited farmers. The papers identify the underlying principles associated with high levels of success in reaching women and men farmers, and describe how, in differing contexts, these core principles have been successfully adapted to fit local conditions in establishing productive, profitable and sustainable relationships with individual producers, producer groups, the private sector, and associated research and education institutions.

The series, and the companion MEAS Working Papers, include papers on a wide range of topics, such as the realities of pluralistic extension provisioning, sustainable financing, human resource development, the role of farmer organizations, linking farmers to markets, the importance of gender, health and nutrition, use of information and communication technologies, and climate change adaptation. The papers target policy-makers, donor agency and project staff, researchers, teachers and international development practitioners. All papers are available for download from the MEAS project website, www.meas-extension.org.

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Table of Contents

Adaptation Under the “New Normal” of Climate Change: The Future of Agricultural Extension and Advisory Services

Introduction

Since the domestication of crops and the emergence of sedentary societies, our species has never faced a more serious challenge than that which we will confront in adapting to climate change. The scale is global, the potential magnitude of impacts catastrophic, the time frame of onset largely unknown, and the threat of delayed action real (IPCC, 2013). Problem recognition, response formulation and preparation are the first steps, and will be iterative as our knowledge continues to expand and new interactions and effects of climate change emerge. Extension and advisory service (EAS) providers have an immensely important role to play in serving as a critical link between farmers and sources of new information and tools, and in aiding behavior change toward adapted practices among farming populations. Perceptions of public extension systems as unimportant and outdated institutions will need to change, as will the performance of public systems themselves. Private sector interests will need to adjust and respond to shifting opportunities, and nongovernmental organizations (NGOs) and donors will need to reinforce and coordinate their actions with the actions of others to achieve impacts of meaningful scale. As the scramble to adapt to the “new normal” intensifies, persistent problems, past failures and new challenges have the potential to converge in a perfect storm. In response, all involved in agricultural adaptation will need to elevate the level and quality of their efforts.

This paper outlines the nature of the adaptation challenge, identifies past and present points of EAS engagement, and proposes future responses. The paper focuses on the constraints and conditions of smallholder farmers in the tropics, as well as the natural resource base upon which agriculture depends. The ideas presented, which are by no means exhaustive, are intended to focus attention, stimulate thinking and urge action at the scale and pace demanded.

The “New Normal”

Major themes

Save for a few instances, EAS providers have never before had to respond directly to the challenges associated with significant climate change. The 20 to 25 percent downturn in precipitation across the West African Sahel beginning in the 1970s and persisting through the 1990s comes as close as any event in recent history to providing a glimpse of what the future may hold, with several important differences. First, the onset of change was extremely rapid in the Sahel, with precipitous decline in rainfall occurring around 1970. Outside of scenarios associated with abrupt climate change, we are unlikely to see such immediate, dramatic change in the current context (IPPC, 2013). Also, rainfall patterns across the Sahel during that period settled around a new norm, and there were no other significant climatological changes occurring within the region at the same time (e.g., comparable temperature change). Global climate change will be different. As far as we know, and depending on humanity’s response, change may continue well into the next century with impacts felt over the next millennium

(IPCC, 2013). There will be no return to prior conditions over the course of individual lifetimes, and changes will continue on multiple fronts with rising temperatures, changing amounts and patterns of precipitation, and changes in other features of continental-scale weather systems (IPCC, 2013).

Climate change will exert increasing pressure on our ability to meet other major challenges, with feeding the world's growing population paramount (9.6 billion by 2050; UNDESA, 2013). Over the next 40 years, the need to increase global cereal production by a minimum of 60 to 70 percent (FAO, 2009; USAID, 2013) will require the addition of global grain production in 1979 and 1985 respectively on top of current production (FAOSTAT[1]). This added demand will place extraordinary pressure on forests, fisheries, hydrologic systems and soils that are already overburdened, and it is particularly troubling for areas where people depend on already degraded systems for their survival.[2] The environmental impacts of meeting rising food demand will be intensified by climate change as global warming and changes in associated climate features accelerate degradation processes in vulnerable environments and lead to unknown interactions and feedback in the complex web of relationships among social, environmental, economic and food systems with "uncertain consequences" (Ericksen et al., 2009).

Box 1: Definitions of key terms used in this paper in the context of climate change

Vulnerability:

"[T]he degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change" (IPCC, 2007a). Temporal and spatial exposure to different types of climate risks is assumed in this definition, as are potential changes in resilience.

Resilience:

"The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions" (IPCC, 2012).

Adaptation:

"In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate" (IPCC, 2012).

Mitigation:

The efforts undertaken to "reduce anthropogenic [greenhouse gas] emissions or to enhance natural sinks of greenhouse gases" (IPCC, 2007b). In agriculture, mitigation generally refers to the sequestration of atmospheric CO_2 in plant tissue through photosynthesis and its storage in soil organic matter, and the reduction in direct emissions from fossil fuel usage and energy intensive inputs.

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[1] faostat.fao.org

[2] Over 60 percent of the earth's ecosystem services are being degraded or used unsustainably (Millennium Ecosystem Assessment, 2005). The stark conclusion of the 1300 experts from 95 countries contributing to the Millennium Ecosystem Assessment was: "Human activity is putting such pressure on the natural functioning of the Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted."

The increase in global temperatures and change in rainfall patterns are affecting biotic communities and the genetic diversity of land- and ocean-based systems. At the landscape level[3], neighboring and even distant biotic communities influence the health and functioning of one another. By way of illustration, years with drought and greater numbers of dry days will lead to reduced soil moisture in upland ecosystems, resulting in less vegetative cover and elevated risk of increased rates of runoff and soil erosion when rains do come, leading to extensive degradation in areas such as southern India, for example (Meinke et al., 2006). Increased runoff and sedimentation will further degrade downstream coastal mangroves and coral reefs, already under stress from acidification of ocean water through increased deposition of CO_2 (IPCC, 2013). Coastal fish populations that depend on mangroves and reef ecosystems as breeding grounds and sources of food will in turn be affected. Declining fish stocks will lead to increased fishing pressure on the remaining marine populations, resulting in a collapse of coastal economies based on fishing. Sea level rise and increased frequency of extreme weather events will inundate and erode coastal vegetation buffers, further harming vulnerable marine and human populations.

In assisting farmers and rural communities to reduce their vulnerability, increase their resilience and adapt to climate change, EAS providers will face three sets of challenges in promoting the use of natural resource and carbon- and energy-conserving agricultural practices:

a. helping to *mitigate* risks of further climate change through the preservation of existing carbon stocks and reduction of CO_2 emissions from agriculture, and helping to sequester CO_2 already released into the atmosphere in trees and soil organic matter;
b. assisting rural populations to *adapt* their livelihoods to current and future changes in local weather conditions and the evolving status of natural resource systems;
c. helping to strengthen the physical and social *resilience* of natural and human systems to withstand and recover quickly from increasingly frequent and severe weather events (e.g., hurricanes/typhoons, floods, droughts, heat waves).

At the same time, traditional concerns for poverty reduction, economic growth and food security cannot be abandoned. Fortunately, because of the close coupling of the human and natural systems within agriculture, there are potential synergies between the various objectives. Many adaptive measures serve mitigation objectives while simultaneously creating additional sources of income and strengthening household and resource system resilience to climate-related stressors – effectively achieving multiple wins.

It will be imperative for EAS providers to recognize and step into the facilitating role that they can play in helping to strengthen the fundamental connections between natural resource systems and rural livelihoods. The remainder of this section reviews the central biophysical forces of the new normal, briefly examines important implications for farmers and rural communities, and identifies the challenges that climate change poses for EAS providers.

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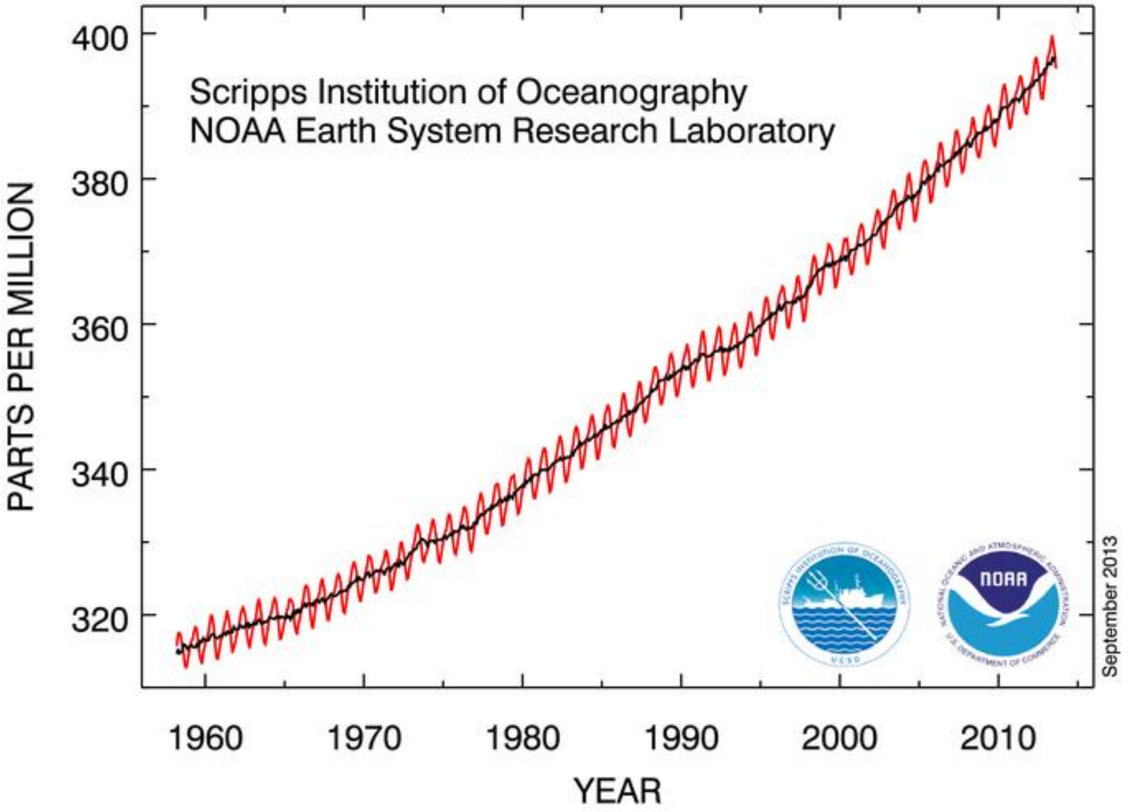
[3] As used in this text, "landscape" is a relative term used to describe the distinct heterogeneous clustering of interacting ecosystems that are replicated at a kilometer-wide scale (e.g., Forman & Gordon, 1986).

Nature of the “new normal”

The immediate task for EAS providers in preparing for and responding to global climate change is simply to understand the nature of the challenge. At the very outset we need to apply appropriate thinking about what constitutes climate change under the current context and abandon notions of a simple switching between discrete states. Climate change needs to be understood for what it is – a process that is continuous, highly complex (non-linear with layers of feedback loops and unknown “tipping-points” that, when exceeded, offer no retreat), and, in terms of human lifetimes, permanent.

Unlike other types of changes that we have confronted in managing natural resources in the past, we have neither the means to readily affect the rate or direction of climate change, nor sufficient knowledge to anticipate the synergistic effects within linked physical and natural resource systems. The hope is that, if we can reduce future greenhouse gas (GHG) emissions, we can mitigate the risk of even more distant changes to the climate. The latent inertia of the atmospheric loading of GHGs, however, is such that even if all additional emissions were eliminated, 15 to 40 percent of the warming effect from past emissions would continue for the next 1000 years (IPCC, 2013). And the fact is that we have barely begun the serious work of reducing future emissions (see Figure 1).

Figure 1. Atmospheric CO2 record at Mauna Loa Observatory, Hawaii, USA



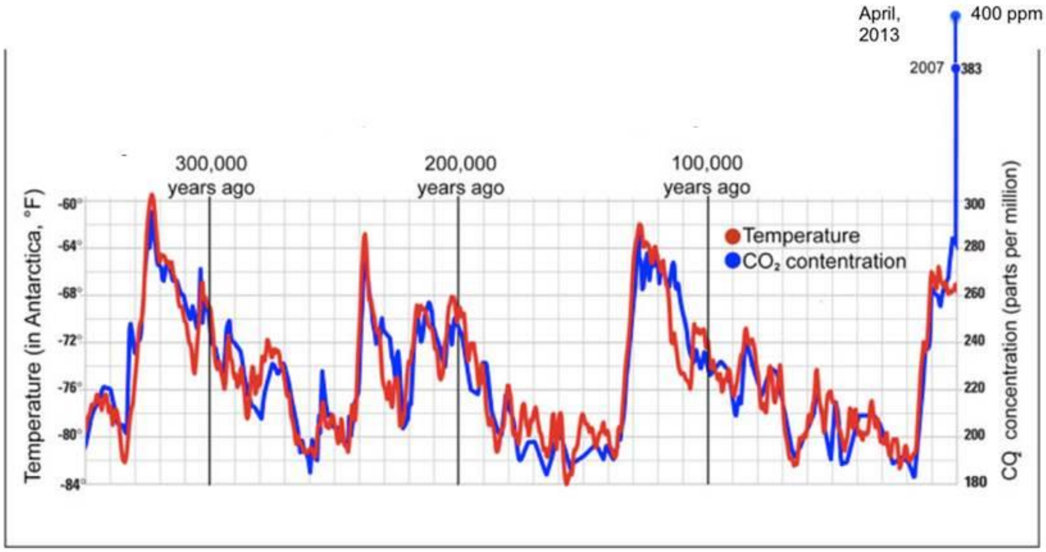
Climate change trends

EAS providers will need to contend with two dimensions of climate change: climate change trends and weather disruption. As the name suggests, increased concentrations of GHGs prevent solar radiation reflected from the earth's surface from escaping the atmosphere, much the same way that a glass roof traps the sun's energy within a greenhouse. Current atmospheric CO_2 concentrations have reached levels not seen in the past 2.5 million years (Biello, 2013). To avoid triggering significant climate change, the upper limit of CO_2 concentration is estimated to be around 350 ppm (Hansen et al., 2008). Concentrations have been rising at an average annual increase of over 2 ppm for the past 15 years and reached 400 ppm in May 2013 (NOAA, 2013). At this rate, planetary CO_2 levels are on track with the most pessimistic scenario in the recently released report of the Intergovernmental Panel on Climate Change (IPCC, 2013). There are no plausible arguments to contradict the prospect that such high levels of CO_2 would have a catastrophic effect on the planet's ecosystems.

The primary outcome of increased atmospheric levels of CO_2 is a heating of land and sea surface temperatures (SSTs) – global warming – which is most pronounced at northern latitudes but experienced worldwide. Over the past 60 years, average global air temperatures have risen by 0.7°C; those in the high latitudes have risen by double this amount (IPCC, 2013; IPCC, 2007a). Every month since February 1985, average global land surface temperatures have exceeded the previous climate period average (NCDC, 2013). The warming of SSTs has been less pronounced because of the mass of the world's ocean bodies and the turnover in ocean water. Decadal warming–cooling cycles in the south Pacific, currently in a cooling phase, are thought to be responsible for the recent slowdown in the rise of global air temperatures (Kosaka & Xie, 2013). When the effect subsides, more rapid warming may occur. Historical records show a close tracking of air temperatures with atmospheric CO_2 levels (see Figure 2). The widening gap between current CO_2 concentrations and average temperatures suggests the likelihood of significant future temperature increases.

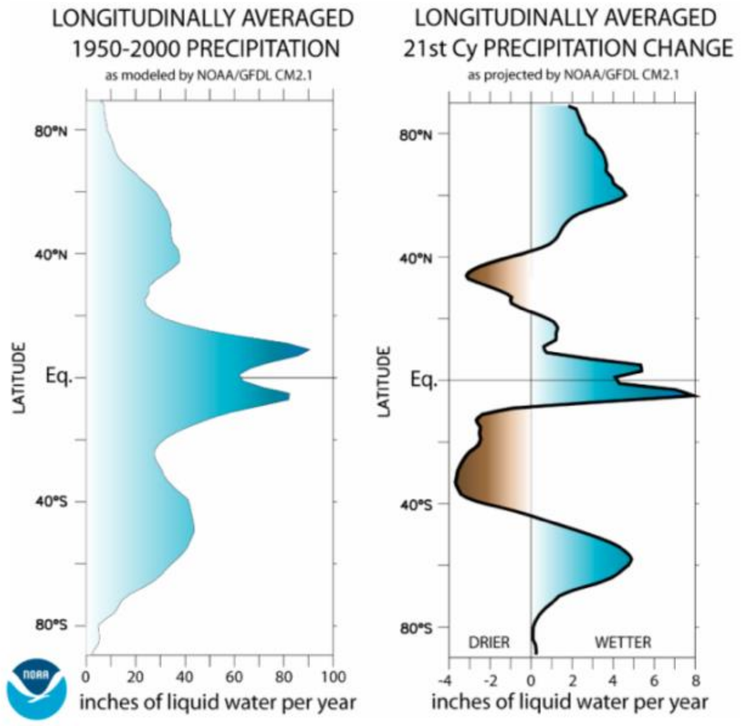
Rising air temperatures trigger several important secondary effects. Increased global day and nighttime temperatures are causing changes to seasonality, especially the onset and duration of warm seasons in northern latitudes, as well as increases in the average, maximum and minimum seasonal temperatures. There are also changes in the onset and duration of rainy seasons in the mono- and bimodal rainfall areas of the tropics. Warmer air temperatures are melting the polar ice caps, northern latitude ice shields and high-altitude glaciers worldwide, leading to changes in the timing and volume of freshwater discharge and rising sea levels. Average sea levels have risen over 20 cm in the past century (most of this due to the expansion of volume as temperatures rise) and will continue to rise as melting of the ice sheets intensifies, adding new water. Warmer air also carries more moisture, leading to more water cycling through the climate system, though its distribution is not expected to be uniform. In general, wet areas are projected to get wetter and dry areas drier, with additional changes to timing of rainy seasons and dry seasons (see Figure 3).

Figure 2. CO_2 and global temperatures



Source: Southwest Climate Change Network, The University of Arizona (www.southwestclimatechange.org/figures/icecore_records), modified from Marian Koshland Science Museum of the National Academy of Sciences (www.koshland-science-museum.org).

Figure 3. Projected changes in precipitation by latitude



Source: Lobell, 2011.

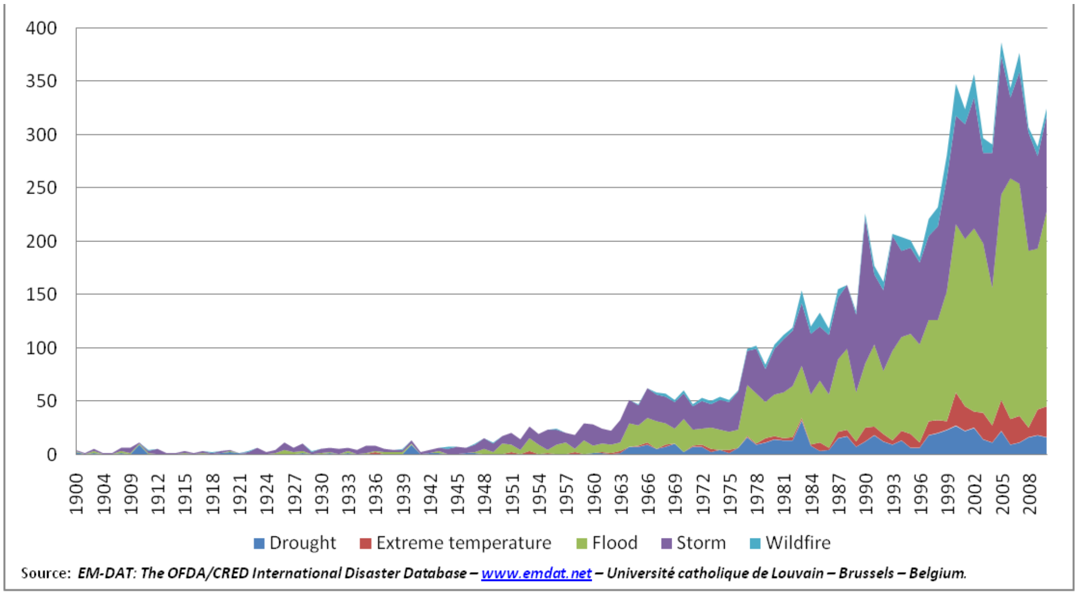
The tertiary impacts of these changes on agriculture are many. Increased air temperatures and changes in seasonality affect the timing of plant flowering, plant–pollinator and pest–predator relationships, especially those involving migratory birds and the overwintering of insect pests. Higher daytime and nighttime temperatures disrupt and accelerate plant maturation during critical stages of flowering and grain-filling and disrupt plant nighttime respiration, all of which contribute to significant yield declines that will erase any positive effects on photosynthesis from higher concentrations of atmospheric CO_2. Empirical evidence for rice, maize and soybean yields, for example, shows an 11 to 17 percent decline with a 1°C increase in nighttime temperatures (Lobell & Asner, 2003; Peng et al., 2004). A comparison of modeling scenarios projects a 30 percent decline for rice and a 15 percent decline in maize yields with a 3°C increase (Easterling & Apps, 2005). By 2100, average growing-season temperatures are projected to exceed the most extreme seasonal temperatures of the past century (Battisti & Naylor, 2009; Gourdji et al., 2013), exceeding the temperature tolerances for many crops in locations where they are now grown. The decline and eventual loss of glacial water sources will drastically affect the systems that depend on these sources of water for irrigation, especially in high-population areas in Asia. Rising sea levels will continue to inundate low-lying coastal areas and islands, causing increased saltwater intrusion in coastal river and groundwater systems, eventually causing the physical displacement of tens of millions of people in flood-prone areas such as Bangladesh, and potentially affecting a tenth of the world's population – those living within 10 meters of sea level (McGranahan et al., 2007).

Exactly when, where and how these changes will be felt – individually, in sequence and in combination – is unknown. What we do know is that these general trends will continue as long as we continue to emit substantial amounts of GHGs, and long after.

Weather disruption

In addition to trends in slow-onset systemic changes, EAS policy-makers, planners and those working directly with farmers will also need to contend with disruptions in established climate patterns in the form of extreme and aberrant weather events – droughts, floods, hurricanes/cyclones and heat waves – that are occurring with increased frequency, duration and severity (IPCC, 2012). As noted above, the additional moisture carried by warmer air and the increased energy stored in the oceans (90 percent of the solar energy trapped by GHGs has been absorbed by the world's oceans) are leading to more intense and frequent storm events, as well as changes in continental monsoonal patterns and regional rainfall (IPCC, 2013). Extreme heat events in areas such as West Africa, for example, which typically occur once in 20 years, are predicted to be occurring once every two years by the end of the century (IPCC, 2012). In addition to changes in the frequency of these severe weather events, changes – especially changes in precipitation – are also occurring in their temporal and geographic distribution. Rare, once-in-50-years, once-in-100-years and once-in-300-years events are beginning to occur with a frequency that redefines their essential character as they become commonplace (see Figure 4). The very nature of these unpredictable, often severe events will require EAS providers to assist with relief and post-trauma efforts, if not directly, then certainly in working with affected populations in rebuilding afterwards (Shepherd et al., 2013).

Figure 4. Numbers of extreme weather events globally, by year



Source: *EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.net – Université catholique de Louvain – Brussels – Belgium.*

Credit: R. Naam, 2013.

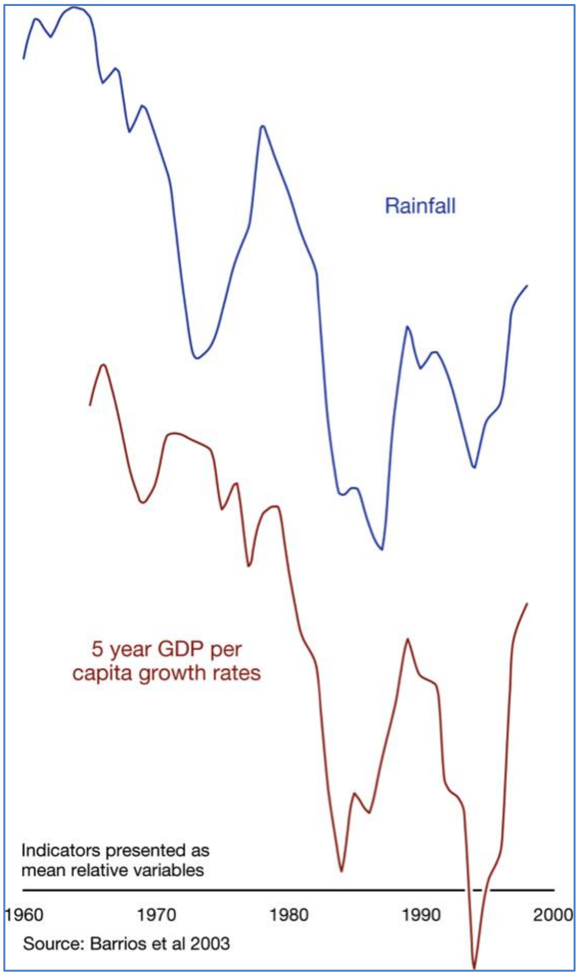
Another effect of climate disruption on human and natural systems will be reduced resilience. In addition to the decreases in productivity in some areas, repeated buffering and rebuilding from severe events will adversely affect human and natural systems in all locations across the tropics. Natural resources and financial reserves will be depleted and unavailable to support or invest in activities that improve long-term welfare and prosperity. This will be particularly true in the case of financial resources, and countries whose economies depend on rain-fed agriculture will be especially vulnerable (see Figure 5) (Barrios et al., 2003). At the farm level, the growing prevalence of severe weather events will change the nature of risks associated with investments in individual agricultural enterprises, especially those that depend on vulnerable local resources for their performance (e.g., those depending on seasonal water sources for irrigation).

Combining these two dynamics – changes in slow-onset climate change trends and increased frequency and severity of extreme weather events – the longer-term temporal perspective reflects the trend (signal), and the immediate perspective of each year is highlighted by the disruptive events (noise). From a farmer's perspective, whether the impacts of the frequency and amplitude of annual events ultimately so dwarf the slower manifestation of trends that the trends become less important, at least until critical biotic thresholds are passed, remains to be seen. It seems nearly certain, however, that these processes will continue to dominate our planet's climate and underscore the need for adaptive responses into the foreseeable future.

Agriculture is not only greatly affected by climate change, it is also a sector that contributes to the problem in significant ways. Globally, agriculture and associated land use changes are the principal drivers of deforestation, responsible for 17 to 24 percent of historic CO_2 emissions (IPCC, 2007a; USEPA, 2006). When combined with direct and indirect energy use, the sector (including food transportation, processing and preparation) is responsible for roughly one third of all GHG emissions (IPCC, 2007b; USEPA, 2006). The bottom line is that the very act of feeding the world's population is a major force inducing climate change, and this effect will likely increase, not decrease, as we struggle to increase food production by the required 60 to 70 percent by 2050.

The interdependencies of petroleum prices and food prices and the contributions of high food prices to civil unrest will make meeting future production targets all the more difficult. Depending on the crop, energy costs for the fuel and fertilizer used in input-intensive agriculture systems – responsible for producing much of the world's internationally traded grain – average between 40 and 60 percent of operating costs (for example, see Sands & Westcott, 2011).

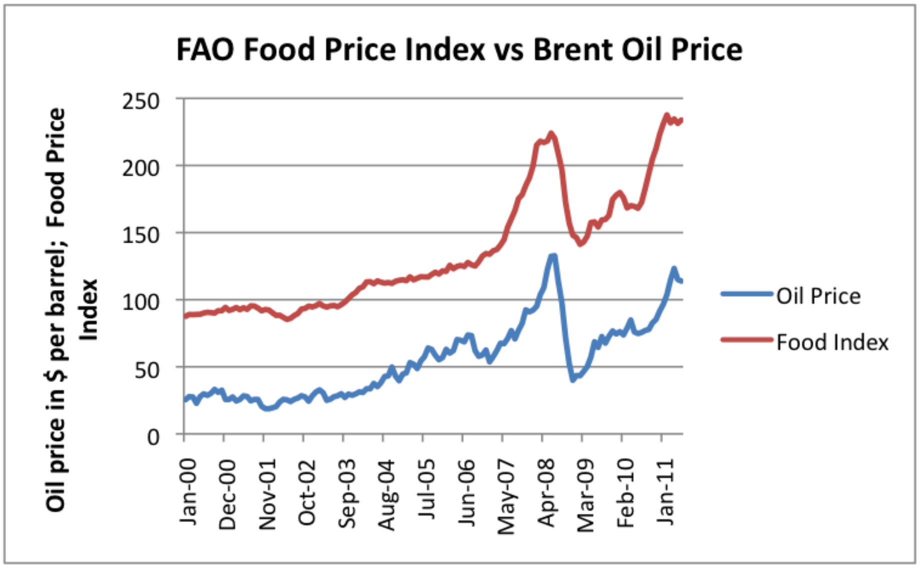
Figure 5. Africa region rainfall and GDP



Source: Barrios et al 2003

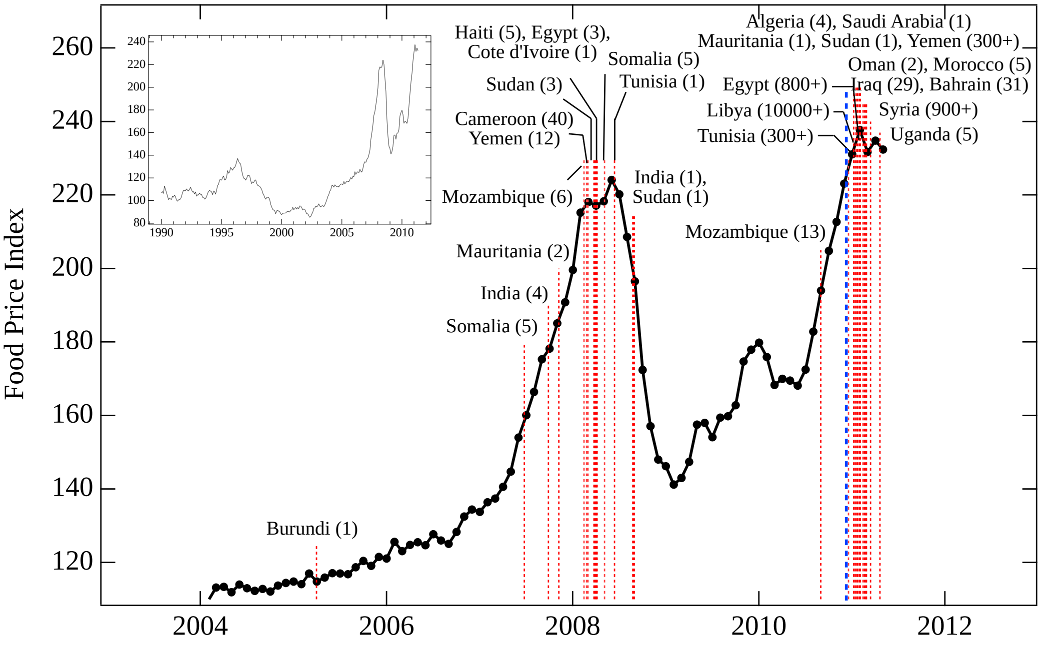
For shipped grain, cumulative transportation costs can contribute up to 40 or 50 percent of the final food prices. In other words, modern agriculture and the global food system are highly vulnerable to changes in petroleum energy prices (see Figure 6) (cf. Headey & Shenggen, 2010). The fluctuation in basic commodity prices can have a tremendous impact on the well-being of the urban poor, who spend 50 to 75 percent of their income on food (Cohen & Garrett, 2009). As was the case with the bread riots in England in the 1700s and 1800s (Archer, 2000), outbursts of civil unrest leading to loss of life and "transition" of several governments were associated with the food price spike of 2007/2008 (see Figure 7). Future increases in petroleum costs will inevitably translate into higher food prices and generate pressure on governments to contain and lower food costs. The use of public funds for subsidy programs designed to keep urban food prices low will make long-term investments in agricultural adaptation to climate change – e.g., research and infrastructure investments – an increasingly difficult priority to fulfill. The trends and disruptive forces of climate change have the potential to serve as an accelerant for the increasingly volatile combination of pressures associated with feeding a planet that will hold 9.6 billion people by 2050 (UNDESA, 2013).

Figure 6. Recent trends in global food and North Sea crude oil price rises, 2000–2011



Source: Tverberg, 2011.

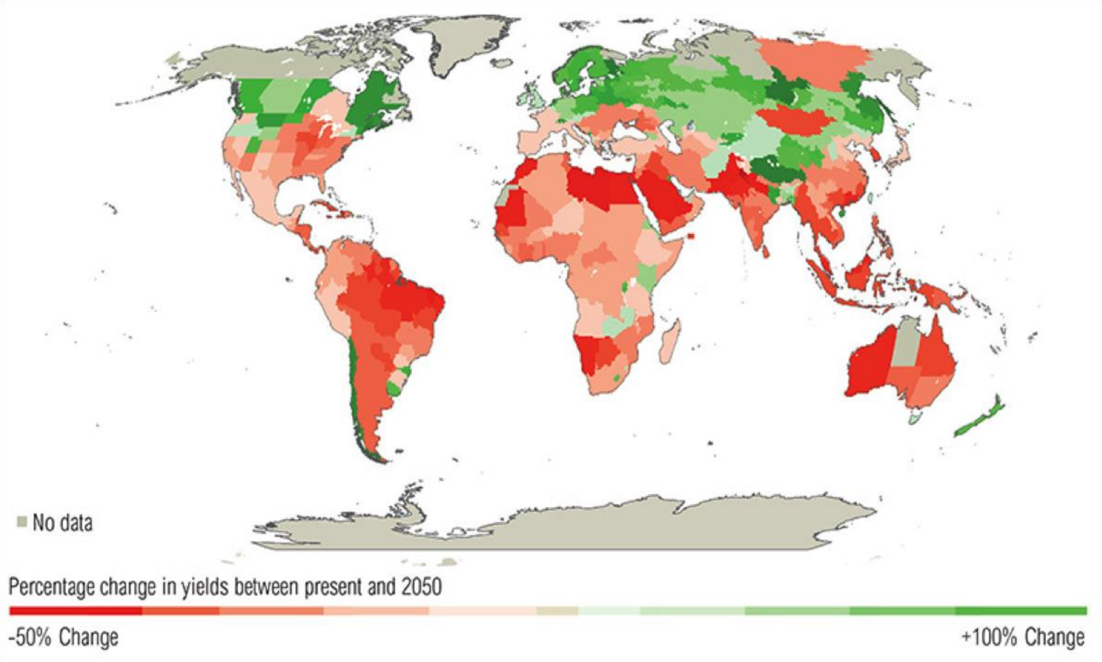
Figure 7. Recent global food price spikes and outbreaks of riots with loss of life



Source: Lagi et al., 2011.

Framed in this way, global climate change presents a problem unlike any other that our species has faced, one with sobering implications for natural resource management and our long-term ability to feed ourselves. It also calls into question our continued ability to rely on agriculture for long-term poverty reduction and economic growth (World Bank, 2008; World Bank, 2010) (see Figure 8). On the whole, the nature and range of professional challenges facing EAS providers will increase, not decrease, as the cumulative effects of climate change manifest themselves. Compounding this pressure is the lack of a comprehensive set of tools and tested practices to assist farmers in implementing the adaptations that are necessary to maintain viable agriculture-based livelihoods.

Figure 8. Projected impact of a 3°C temperature increase on crop yields



Source: World Bank, 2010.

Implications for Smallholders and the Rural Poor

One of the hallmarks of the vitality of rural communities and smallholders is their ability to respond and adapt to changes that affect their livelihoods – changes in weather and natural resources, household labor availability and other assets, fluctuating input prices and product sales, the ebb and flow of external extension and development support, and shifting national policies – all in the context of real-time decision-making. The fewer assets that rural families have – human, financial, natural, social, political, physical – the more challenging it will be for them to cope with change and the longer it will take for them to recover from even modest shocks.

The direct risks of climate change and indirect impacts of climate-induced changes on natural resource systems will increase the vulnerability of the rural poor, making it more likely that they will slide into intractable asset-based poverty traps (Barrett & McPeak, 2006). Much of this vulnerability is linked to a weak financial resource base, absent or eroded management structures, and high dependence on natural resources. Many communities and households already struggle to survive within the context of degrading natural resources. They are not, however, unaware of the changes taking place around them. Older villagers and more experienced farmers perceive changes in local climate that match weather records, and they note that these have been taking place for several decades – less or more variable rainfall, more intense rain when it does fall, more frequent dry spells and droughts, stronger cyclones or hurricanes – along with changes in land use to expand crop production and meet fuelwood needs, resulting in deforestation, soil erosion and declining fertility through reduction and abandonment of fallow periods, increased insect pressures and incidence of disease, all related to the intensification of resource extraction (Bryan et al., 2009; Ebi et al., 2011; Gbetibouo et al., 2009; Maddison, 2007; Trouche et al., 2008).

Lack of household savings and access to formal and informal credit leaves individual farmers unable to invest in capital-intensive alternatives or to access funds to cope with a crisis and prevent further damage to or loss of other assets. Collectively, legal tenure systems in many countries undermine farmers' formal control over natural resources or fail to regulate access and over-extraction by outsiders. When these are paired with missing or ineffective local management structures, the ability of farmers to manage natural resources is further weakened, and their vulnerability to climate-induced trends and shocks increases. Climate change will accentuate the need to link individual agricultural decisions with larger landscape and land use management challenges.

Individuals and communities can be slow to implement natural resource management (NRM) changes, especially in locations with high proportions of vulnerable households, without improved access to markets, available credit, or immediate, observable benefits in productivity, such as plant response to increased fertility, reduced weed growth or improved water availability during dry spells (Marenya & Barrett, 2007; Shiferaw et al., 2009). Unfortunately, the positive benefits of most NRM changes take time to manifest and are easily masked by seasonal stresses. For example, the buildup of soil organic matter, which leads to increased nutrient availability and moisture retention; it takes years to augment topsoil depth, during which time the benefits can be easily overshadowed by perturbations in seasonal rainfall. The same can be said of the positive benefits associated with tree planting, establishment of vegetative barriers, conservation tillage and other resource-conserving technologies. Although realization of some of the positive benefits takes years, the adoption of NRM practices generally comes with immediate financial, labor and productive opportunity costs. Increasing changes in local weather patterns, including more frequent severe events, however, will accelerate smallholder needs to take up new NRM practices. Disasters, in particular – as the following section will illustrate – can trigger rapid, widespread behavioral change that EAS providers must be prepared to capitalize on.

Challenges for Extension and Advisory Services

Assisting farmers and rural communities to adapt to the direct and indirect effects of climate change challenges the role of EAS providers in two ways. First there is the technical challenge of determining when and where to invest limited human and financial resources in assisting farmers to select which types of specific adaptive changes to make – essentially, determining the technological and adaptive practice switching points. The timing of when to make successive changes to adapt to an evolving climate – e.g., switching to varieties with increasing tolerance to rising temperatures and, ultimately, changing which crops are planted – will present the greatest challenge. The second challenge, related to the first, will be one of enhancing technology exchange, adaptation and dissemination practices to match the need for continual climate change adjustments. These two EAS challenges are elaborated in the following sections.

Adaptive practice switching points

To be effective, the choice of EAS responses needs to be matched to the location-specific problems faced by farmers and provided at a scale that matches the challenges. EAS programs need to consider how to coordinate between those efforts best undertaken at the field level and those on the landscape level to achieve maximum efficiency. The challenge lies in helping farmers and rural communities transition from current to anticipated future conditions while striking a balance between short-, mid- and long-term goals of productivity maximization, vulnerability reduction and enhanced system resilience. Some complementarities exist between scale and time frames, but there are also some hard choices, and all are associated with real costs that must be met within a context of limited financial and human resources.

The events surrounding the impacts of Hurricane Mitch illustrate the importance of timing and scale. Immediately after the 1998 hurricane, which dumped over 1.2 meters of rain on the mountainous areas of Central America, families who had resisted planting live contour barriers to stem runoff and erosion were able to compare the loss of their hillside plots with the condition of neighboring plots protected by well-spaced vetiver hedges and rock barriers. To assess farmer responses, a multi-agency research project compared the impact of Mitch on a total of 1800 farm plots, half under conventional management and half under the more sustainable suite of conservation agriculture practices. The study covered three Central American countries and involved 2000 participants and 40 organizations (World Neighbors, 2000). Plots under conservation agriculture practices sustained 58 to 99 percent less damage, retained 28 to 38 percent more topsoil and suffered two to three times less surface erosion than conventionally managed plots. On the other hand, gullies and mudslides that originated uphill on degraded, deforested lands damaged both conventional and conservation plots below with equal force. Viewing the differences, households that had previously ignored NRM training opportunities and adoption of NRM practices immediately began to demand training, and the adoption of “new” practices and technologies soared.

The lessons for EAS providers from this example are twofold. First, behavioral change – typically focused on the management unit of the household – needs to be targeted at the appropriate scale to address problems affecting larger ecological units; in this example, hillsides within an entire watershed. Secondly, just as the global food price spike of 2007/2008 refocused attention on agriculture and food security, EAS providers will need to use observable evidence of slow- and rapid-onset climate change events to focus farmers' attention on the importance and interrelations of NRM practices and agricultural management alternatives. In the language of extension educators, they need to capitalize on the teachable and learnable moments.

To effect landscape-level changes in NRM, EAS providers will need to work with and through multi-stakeholder decision processes, help broker agreements, strengthen management structures and mediate conflicts. Traditional NRM interventions include promotion of reforestation and recuperation of vulnerable or degraded ecosystems, establishing (or reestablishing) control of overgrazing and land clearing, and protecting biodiverse areas, coastal zones and freshwater wetlands, among others. Landscape-level management strategies and decisions will include making choices about the nature and timing of changes to overall land use, taking into account information about who or what may stand to benefit (or lose) from environmental services. Specific decisions related to climate change adaptation may include:

- when to switch to varieties and crops with greater tolerance to emergent climate change stressors;
- when to modify or switch land-use systems – for example, from annual crops to perennial species with more extensive root systems that access water sources out of reach to annuals and that withstand more intensive rainfall events;
- when to transition from rain-fed production to supplementary irrigation as the frequency and length of dry spells increase;
- when to augment and increase the capacity of drainage systems to handle extreme rainfall events;
- when to shift use of land types – for example, in dryland environments, moving from increasingly vulnerable drought-prone uplands to concentrate on better watered lowlands, or moving out of increasingly flood-prone riparian areas;
- when to diversify out of agriculture and ultimately abandon certain activities or areas altogether as they become untenable as zones of production.

The emerging stressors of climate change require integrated interventions that link plot-level decisions with larger planning frameworks – value-chain development and landscape-level management. In response, the search for areas of positive synergism between field-level decision-making and landscape-level NRM will be another important theme in EAS engagement. Structurally, however, few public-sector extension systems are organized in a manner that facilitates close integration of NRM and agricultural outreach efforts. The individual country assessments carried out by the USAID-funded Modernizing Extension and Advisory Services (MEAS)[4] project, and the Worldwide Extension Study[5] carried out by the

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[4] www.meas-extension.org/meas-offers/country_studies

[5] www.worldwide-extension.org; www.g-fras.org/en/world-wide-extension-study

International Food Policy Research Institute (IFPRI) – supported by USAID in collaboration with the United Nations Food and Agriculture Organization (FAO) and the Inter-American Institute for Cooperation on Agriculture (IICA) – show that, in most countries, agricultural and NRM extension efforts are carried out by separate organizational structures, each with its own staff working in different geographic areas and employing different methods to pursue different objectives. And this is to say nothing of the plethora of independent donor-funded NGO- and contractor-implemented projects. In sub-Saharan Africa, in particular, the provision of extension services tends to be separated among crop, livestock, fisheries and forestry line ministries or departments, often with weak or no cross-ministerial communication. There are exceptions, such as Malawi, where the same public-sector extension field agents support the full range of crop, livestock, fisheries, forestry and irrigation programs. The upside in having a single point of entry at the community level is that it provides an opportunity to achieve coordination between various initiatives. The downside is that the demands placed on individual field agents to become universally knowledgeable across the entire spectrum of agricultural activities far exceed their training and the programmatic support they are offered (Simpson et al., 2012). If not properly managed and coordinated, pursuit of multiple objectives can lead to the overloading of frontline workers and confusion at the field level. The nature of the challenges, however – natural resource degradation, food insecurity, rural poverty and climate change adaptation – calls for stronger integration of NRM and agricultural EAS within a highly integrated planning framework (Hunt et al., 2011; Johnson et al., 2006; Swanson, 2008).

Closer functional linkages will also need to be established between EAS and research programs. Criticism of the training and visit system (T&V) aside (Anderson et al., 2006), one area where T&V excelled is in establishing and maintaining close working relationships between extension and research efforts through regular meetings and established review and reporting procedures. Such close relations are missing from most current extension programs. In fact, fieldwork in countries such as Kenya, Malawi and Mali reveal an alarming, consistent pattern of disconnect between national research and extension programs. These divides will need to be closed and working relations established (or reestablished) if EAS programs are to benefit fully from potential research contributions, and if research programs are to benefit from a clearer understanding of the needs, challenges and progress made by farming communities in adapting to climate change.

Overall, the challenges and choices facing EAS providers are varied and complex, residing in specific locations and at different scales. The temporal phasing between adaptive responses is never clear because it depends on: local and external resources; individual, social and institutional capabilities; evolving markets; and national policy frameworks. Individual technology and management choices that offer benefits under a specific set of conditions are often suboptimal outside of specific contexts. Once taken, some choices may preclude following other action pathways and require resources and costs that must be considered. Some options involve significant lead times – e.g., for tree planting, irrigation system development or breeding efforts for improved resilience – that must be anticipated if they are to deliver full benefits during their window of opportunity against the background of continually changing environmental conditions. Choices offer varying degrees of robustness in their ability to meet a range of possible climate futures. And in all cases, there are limits to adaptation.

Determining the proportion of resources and the amount of effort to allocate to landscape-level versus farm-level interventions, and determining the timing, nature and location of specific interventions, will be the most difficult operational challenges facing extension and research programs in assisting farmers and rural communities to adapt to climate change. Some practices offer what are termed “no-risk” or “no-regrets” changes that serve multiple objectives, such as building up soil organic matter, maintaining year-round vegetative cover in humid zones, and investing in improved water-harvesting practices in dry areas to strengthen system buffering capacity and enhance productive potential. The levels of knowledge and skills required by frontline staff members to match various opportunities with site-specific needs, as well as EAS program flexibility and responsiveness, surpass any that are currently in place yet define the path forward in preparing for life under the new normal.

Enhancing effective technology exchange, adaptation and dissemination

The second EAS challenge, related to the first, involves enhancing effective technology exchange, adaptation and dissemination. In preparing to assist farm populations and communities to adapt to climate change, reduce vulnerability and strengthen resilience, EAS providers can look in three directions for guidance: historical lessons of how others have responded in adapting to significant changes in climatic conditions; lessons from what others are doing now in progressively drier, wetter, hotter and/or more disrupted environments that could be used as models for areas anticipating similar changes; and lessons that may be generated from focused research efforts relating to new or best-bet responses to address projected future conditions. Rapid and effective technology transfer and adaptation involving the knowledge and tools emerging from both formal research systems and indigenous responses will be two of the greatest tools at an EAS provider’s disposal. The ability to skillfully identify and efficiently assess, modify, test and exchange useful technologies and practices from around the world will be increasingly important in adapting to climate change impacts as research systems struggle to keep pace with new and evolving problems (e.g., Ramírez-Villegas et al., 2011). Technology transfer will buy valuable time.

One immediate challenge is the lack of a unified global agricultural knowledge system. The many international, national and project-based research programs, in combination with the separation of research and applied development efforts, have resulted in a proliferation of repositories of research results and practice-based lessons that are effectively unavailable for use. The assumption that current research and development practices reflect the sum total of past learning does not stand up under examination. The cyclical revisiting of the same research themes and technologies (e.g., natural rock phosphate, fodder banks, fuel-efficient stoves, among many others) (Simpson, 1999) reflect changing donor interests and the transition of researcher cohorts. The problem is particularly acute in research systems that have been isolated from international exchanges, cut off through underfunding. In a review of USAID-funded maize, rice and sorghum research networks in West Africa over a 20-year period, participating scientists unanimously cited the immense value of having the opportunity to meet, exchange and participate in joint research efforts with their peers from neighboring countries struggling with the same issues (Clarke et al., 2004). Beyond case studies and anecdotal reporting, contributions to research and knowledge of agricultural systems from NGOs have not been significant despite the vast sums that have been channeled through these organizations, and for-profit firms, to implement development activities over the past 25 years (e.g., White & Eicher, 1999). Despite efforts during the 1990s, traditional knowledge systems and local adaptive capacities, which have evolved through centuries of adaptation to weather fluctuation and other changes, have never been well understood or broadly mainstreamed into ongoing research and development efforts. In sum, we are collectively ill-prepared to rapidly draw upon and utilize the wealth of agricultural knowledge that has been generated over the course of human history.

The Road Ahead

The approximately 2.5 billion smallholder farmers (IFAD, 2013) who manage a majority of the nearly 22.2 million square kilometers of the earth's surface under agriculture (Zomer et al., 2009) represent a tremendous force in our ability to utilize NRM practices to help mitigate the negative impacts of future climate change and they form a large part of the target domain for EAS programming. The underlying premise of using agriculture as an engine for economic growth, poverty reduction, increased food security and now adaptation to climate change is predicated on effecting significant and widespread behavioral change involving the development and adoption of more productive, more recuperative, less wasteful and more profitable agricultural technologies and management practices. Working with farmers to effect behavioral change within natural, social and economic systems that are essentially stable is one thing. Working with the rural poor under the new normal – in a context of continual and increasingly disruptive change – is another. To effect behavioral change, EAS providers will first need to address the issue of helping farming populations understand that the new normal really does represent a departure from the past, and that responding to it will require adoption of truly adaptive measures and not simply belt-tightening and coping until conditions return to the way they used to be. Another feature of the signal/noise trajectory of climate change is that there is no going back. To respond to the breadth of challenges of adapting to climate change, EAS providers will need to (i) reconsider their strategies and operational frameworks for engaging rural populations, (ii) increasingly work with groups at appropriate scales, (iii) overhaul training curricula and (iv) maximize use of advanced information and communication technologies, and (v) advocate for supportive policies. The remainder of this paper addresses each of these issues in turn.

Evolving strategies and frameworks

The systemic nature of global climate change will require use of commensurate systems thinking to proactively engage the quadruple climate change challenge of mitigation, adaptation, decreased vulnerability and increased resilience within the agricultural sector. The abandonment of support for the farming systems research and extension (FSR/E) paradigm by donors in the early 1990s has regrettably (though predictably) been accompanied by a nearly complete loss of formal systems analysis in applied agricultural research and extension practice.

The use of certain modeling platforms, such as the decision support system of agrotechnology transfer (DSSAT), allows mechanistic examination of discrete management variables (Jones et al., 2003) but is removed from the realities of farm-level decision-making and does not foster learning about why changes are or are not being made. Throughout its history, efforts in community-based NRM (CBNRM) have faced an uphill struggle in attaining effective local participation and in linking ecosystem management to local control and equitable resource distribution, a task often compounded by ineffective resource rights and conflicting agendas of various actors (Hill et al., 2010). The sustainable livelihood approach (SLA), supported by various donors (Hussein, 2002), is realistically broad in its target – engaging livelihood contexts to build assets, reduce vulnerability and increase resilience while supporting needed change in institutional systems – but usage could be improved, especially in agricultural applications. It will be instructive to track the progress of efforts directed toward building a climate change adaptation focus into SLA-orientated field programs (e.g., Meena & O'Keefe, 2007). As with SLA, the farmer field school (FFS) approach is also being modified for use in addressing the challenges of climate change (Winarto et al., 2008). In both instances – SLA and FFS – questions over implementation costs need to be addressed to achieve a base of sustainable financing at scales that matter. For all the talk of comprehensive engagement "up and down the value chain," few value chain development efforts extend their focus beyond one or two key relationships – e.g., producer groups and buyers, processors and consumers – or include consideration of upstream impacts and sustainability of farmers' production systems. The literature is void of clear examples of value chain projects including a systemic consideration of risk reduction and responsive adaptation to climate change as part of their design, although, increasingly, project implementers and donors are revising interpretations of their intent – some justified, others not. The payment for environmental services (PES) framework offers a conceptually rich subset of value chain development activity but has encountered stiff challenges in bringing what economists have traditionally termed "environmental externalities" into the marketplace. Watershed management and the "wild west" environment of the carbon-offset markets are probably the two PES action areas most relevant to EAS climate change efforts. Transaction costs and, in the case of carbon offsets, the costs of measurement, reporting and verification systems have proven to be effective barriers to widespread smallholder involvement.

Overall, systems thinking surely has a diminished presence in the agendas of most agricultural research and extension programs, if it hasn't been lost entirely. The trend over the past 20 years has been a return to positivist thinking, a reversion to the framing of research questions in simplified forms, isolated from complicating features of smallholder and institutional realities. One can hope that we are in a transitional phase and that more holistic climate change vulnerability assessment and adaptation planning procedures will become central features in development efforts. Given the nature and breadth of changes that are taking place under the new normal, without engaging in broad systems thinking and consideration of interactions, it is difficult to envision how appropriate responses will be forthcoming.

The anticipated impacts of the new normal, however, will require a different sort of systems thinking than was pursued previously. In the past, FSR/E efforts focused on enhancing the productivity, stability, sustainability and equity of production systems (Conway, 1985) within comparatively stable environments, and struggled with diverse, complex, risk-prone environments. Adaptation to wholesale system change, let alone a process of continuous change, was not on the agenda. Efforts tended to focus on investigating and attempting to understand and refine efficiencies in the many detailed aspects of system functioning – reasonable targets for systems under essentially stable ranges of conditions. Under the new normal, systems thinking will need to engage more broad-based system principles that hold over a wider range of conditions and recognize that the process of continuous change will not allow such in-depth investigations of system interactions. For example, precise recommendations on optimal intercropping associations – including crop and variety choice, plant densities, spacing and planting patterns – will quickly become irrelevant with any significant change in rainfall patterns and the passing of crop temperature thresholds. Basic principles relating to soil organic matter management, protection of critical water sources, and competitive and facilitative plant production interactions, however, can be applied in endless configurations involving different crops and varieties across a range of climate regimes, with farmers working out the application of these principles in practice. Many of these production principles were the subject of the agroecological research carried out in the 1980s and are now the focus of research on organic agriculture, and they will become an increasingly valuable resource as we move forward (e.g., Altieri, 1987; Conway, 1985; Francis, 1986; Gliessman, 1990; Vandermeer, 1989). The same is true for the many complementary techniques and methods of involving farmers in research efforts and feeding farmers' own innovative capacities that were developed and refined beginning in the late 1980s through the early 2000s.

Fortunately, within the domain of NRM-oriented agriculture many land management principles confer broad-based, system-level benefits that allow farmers to contribute simultaneously to mitigation efforts while making needed adaptive responses and enhancing the resilience and profitability of their livelihoods. As one example, the planting of trees in agroforestry associations increases carbon sequestration in above- and belowground storage. Also the pumping action of roots and biomass production can bring into circulation soil nutrients that are stored in the soil profile below the root zone of annual crops, thereby enhancing crop productivity. Tree litter helps to build soil organic matter, thereby increasing the moisture-holding capacity of the soil. The physical presence of trees and their rooting strength help to guard against soil erosion and landslides caused by intensive rainfall events, as well as providing shade and reducing ground-level wind speed, thereby reducing evapotranspiration associated with higher temperatures. The addition of perennial species can diversify the range and timing of harvested agricultural products and can provide products with potentially high market value. Many perennial species have broader tolerance to environmental stresses than annual crops have. Benefits conferred by individual changes can be further enhanced through the addition of complementary practices involving other features of the production system, such as the introduction of companion soil and land management practices (e.g., terracing, use of rock lines, vegetative barriers, crop residue maintenance and no-till cultivation) in agroforestry projects, such as the example described above. The identification of areas of synergism and their associated market and non-market drivers requires a broad systems perspective and will be of growing importance in EAS programs under the new normal.

As noted previously, smallholder producers face the prospect of having to make a cascade of site-specific adaptive responses during their lifetimes, each change offering a bounded response to the challenges of continued climate change. One of the first adjustments that farmers made in responding to climate change in the Sahel, beginning in the 1970s, was in the reallocation of land among crops and varieties already cultivated, increasing the use of existing genetic resources that favored the prevailing conditions. In some locations of southern Mali, farmers switched from rice cultivation in the extensive floodplains to maize in those same locations when seasonal flooding was reduced (Simpson, 1999). A second-level response observed was the active search for new varieties that extended farmers' range of use of known crops, such as new early and extra-early varieties of maize that better matched the shortened rainy periods. A third type of adaptive response was farmers shifting to entirely new crops in response to failure of annual cereal crops, such as growing cassava as a food security crop in areas where cassava had not historically been planted. Farmers also adopted new land uses with which they had little or no previous experience, such as the de-emphasis of upland cultivation and concentration of efforts and resources in better-watered lowland areas or adoption of technologies (e.g., pumping) that achieved the same effect. Lastly, as adaptive thresholds were eclipsed, the Sahelian droughts led to the abandonment of areas and agricultural activities that could no longer be sustained. Such was the case for pastoral herders who had lost their herds completely or were forced to liquidate the remnants of their herds; they moved to cities or southward to moister environments and took up sedentary agriculture and the management of herds of established agriculturists (e.g., Mortimore & Adams, 2001). The lesson in these observations is that EAS providers will need to programmatically prepare to help farmers undertake a succession of adaptive responses to emerging stressors of climate change.

Another important lesson in the examples cited above is that, save for the introduction of new varieties, all were indigenous responses. Although the promotion of engaging indigenous knowledge systems during the 1990s can be seen largely as aspirational, engaging indigenous capacities for adaptation under increasingly rapid climate change will be essential. In the context of the new normal, the greatest advantage of the formal research system is the capacity to engage in anticipatory analysis, development and dissemination of responsive technologies – for example, the development of new heat- and drought-tolerant maize varieties and the development of submergence-tolerant rice varieties by the international agricultural research centers (Cairns et al., 2013; Septiningsih et al., 2009). In contrast, formal research and EAS processes will likely prove too slow in responding to the real-time and disparate needs for more nuanced management adjustments by farmers in specific contexts. As illustrated above, the switching points between individual and collections of technologies and management practices are so uncertain and locally dependent – based as much on the status of individual household and community resources as on natural conditions – that research programs and EAS providers will need to concentrate on agricultural principles and facilitative means of engaging with farmers in responding to climate change stressors. Continued practice of promoting prescriptive, general recommendations focusing on short-term optimization will become increasingly ineffective in responding to evolving local realities. The need to rely on and feed farmers' inherent adaptive capacities will be an integral part of EAS operational strategies. Overall, the potential of trends heading in opposite directions – e.g., increasingly long rainy seasons with decreased continuity of rains within seasons, and opposing disruptive events, such as the increased occurrence of floods within drying trends – will make adaptation particularly challenging for all those involved.

Working with people

Regardless of the source of innovations, most EAS providers will need to engage in iterative cycles of experimentation and learning as they begin to work with rural communities in testing high-potential adaptation practices while risks are low. In most contexts, the optimal entry point will be selection of what are characterized as "no-regrets" strategies (Heltberg et al., 2009) – those changes to local ecosystem and NRM practices that will increase overall resilience and productivity regardless of whether anticipated climate-induced shocks materialize. Consistent, ongoing EAS support in NRM-centric agriculture will be critical for effective mitigation and adaptation efforts (see Box 2). Most technical options will require capacity strengthening and the support of community engagement. Regrettably, in many countries the history of NRM is rooted in a period of "coercive conservation" during which fines and threats of imprisonment were used to induce compliance (e.g., forest codes in West Africa [e.g., Boffa, 1999], and enforced terracing and soil conservation practices in East and Central Africa [e.g., Stocking, 1985]). These practices left local populations disenfranchised, more vulnerable and poorer (Dressler et al., 2010; Hill et al., 2010; Pretty & Shah, 1997; Shackleton et al., 2002). With time, more participatory and empowering NRM-focused agriculture approaches have coevolved with policy changes, but despite its widespread success, CBNRM has faced an uphill struggle in attaining effective local management, linking local control and promoting equitable resource management.

Box 2: Adaptable farmers

In a tobacco-producing area of Danlí, Honduras, researchers visited farmers in the community of Alauca to learn about local farming, share climate change predictions and discuss ways to avoid crop losses. These southern farmers said they would simply accept what the future brings.

Meanwhile, in Jamastran, about 100 km to the north, researchers discovered that farmers were already adapting to climate change – diversifying their crops, installing simple irrigation systems, practicing soil and water conservation, and marketing products as a group. When asked why they were doing so well, the northerners explained that, for a few years, they had received **continuous extension,** first from the private sector and later from the national extension system. What they learned gave them the confidence and skills they needed to adapt early to changes in the weather.

Source: A. Schmidt, personal communication.

In spite of the challenges, the scale of climate change impacts is such that strengthening social capital for collective action and strengthening the local knowledge base on local ecosystem functioning are essential parts of an adaptation strategy to climate change. Communities that have not been torn apart by armed conflict or that are not made up of recently resettled populations have a deep attachment to the areas where they live. Their collective history of environmental knowledge provides them with important assets for managing local natural resources. The shared knowledge and relationships of trust with one another and known points of opposition are the foundation for establishing effective co-management structures, especially if they are fortified by strong community organizations, technical support for sustainable resource use and policies codifying local resource rights (Brunckhorst, 2010). Ferse et al. (2010) found that community involvement in environmental design for access, use and protection of natural resources resulted in more adaptable, flexible management and more resilient ecosystems. Furthermore, when social networks included a mix of actors in the same watershed, those actors who had links to additional sources of information were able to bring new perspectives and opportunities that helped to increase resilience through adaptive management responses (Bodin et al., 2006).

It bears repeating that EAS providers have a key role to play in establishing long-term adaptive plans involving environmental rehabilitation and equitable sharing of benefits, rights and responsibilities. In watershed development efforts, specific activities include supporting formation and strengthening of watershed committees, mapping watershed resources and identifying resource linkages; convening meetings and forging agreements between upstream and downstream users, local government officials, businesses and community groups; analyzing current and potential land use options; identifying degraded areas and water sources for priority reforestation and protection; and outlining a plan for a manageable succession of interventions (Bodin et al., 2006; Brunckhorst, 2010; Dressler et al., 2010; Ferse et al., 2010; Hill et al., 2010; Pretty & Shah, 1997). An example of this type of phased strategy comes from the 13-country, multi-agency Global Water Initiative in East and West Africa and Central America, where communities received five years of extension support for mapping, assessments of watershed health, and improved understanding of basic relationships between soil, plants and water.[6] Communities in some of the participating countries are now using their own money to buy or lease land above springs and fencing off these areas for tree planting or farmer-managed regeneration to improve water infiltration. Government officials involved in these efforts are redrawing political boundaries to match watershed boundaries and collaborating across political divisions to manage transnational watersheds. If we in the international research, extension and development community can avoid wasting the opportunity that the crisis of climate change brings, these sorts of efforts may help facilitate adaptation to the new normal.

Curriculum and information and communication technologies

The management of local opinion regarding adaptation to the new normal will likely become part of the EAS work portfolio. Avoiding panic and destructive short-term behaviors, as well as

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[6] www.globalwaterinitiative.com/index.php/about-us

addressing the despondency of indigenous populations losing a sense of place, are real concerns. Here, engendering trust and credibility with local populations will be key. To help prepare EAS practitioners for the growing technical and methodological challenges, pre-service education programs will need a major overhaul, and a process of regular in-service updates will need to be established. Only recently has the importance of investments in tertiary (college-level) agricultural education programs come back onto the development agenda. Given the cumulative neglect, needs vastly exceed the resources being committed. In one example, a long-term national assessment was commissioned that identified the need to train 364 specialists to graduate-degree levels (M.Sc. and Ph.D.) within the key agricultural ministries and programs. The estimated cost was over US$ 11 million (Edwin et al., 2003). The agency response was to implement a single US$ 300,000 three-year project that targeted the training of seven researchers (two to M.Sc. level), enabled through matching and supplemental funding (HED, 2007). USAID's recent launching of the Modernizing Agricultural Education and Training Systems project is a positive start, though other donors, as well as national governments, will need to begin taking the worldwide human resource crisis in agriculture seriously. One of the common findings in the EAS assessments carried out by the MEAS project to date is the aging population of public-sector extension field staff; on average the members are within a decade of retirement (e.g., Simpson & Dembele, 2011; Simpson et al., 2012). The gaps that will be created as this aging cohort retires, combined with the current absence of EAS in-service training programs (Simpson & Dembele, 2011; Simpson et al., 2012; Simpson & Singh, 2013) and the legacy of abandonment and decay within agricultural education programs, will exert themselves for years to come, just as the pressures for a better educated and more capable EAS workforce are making themselves felt. Though particularly acute in Africa (e.g., Eicher, 2004), the neglect of human resource development is by no means an African crisis alone (BIFAD, 2003). The opportunity, therefore, exists to revitalize national training programs to prepare the next generation of EAS practitioners for the realities they will face. Cumulatively, the challenges of responding to conditions under the new normal will continue to expose our collective failures in addressing many areas of the development agenda; the underinvestment in education is but one.

The potential contributions of technological innovations – including the staff trained in how to use them and the data inputs required to power them – in helping to facilitate sustainable development efforts have been promoted for over a decade (NRC, 2002). Outside of the research community, however, little progress has been made. In contrast, the Famine Early Warning System Network (FEWS NET[7]), possibly the longest-lived USAID technical program, will likely see increased use in the decades ahead (although this too has been predicted for decades). To help capture the geographic and temporal dimensions of climate change impacts, climate and crop models, remote sensing and geographic information system (GIS) technologies all have important roles to play in assisting policy-makers and research and extension program managers in targeting their respective efforts. One example of combining the predictive capability of climate and crop modeling with soil and geographic data is the collaborative work undertaken between Catholic Relief Services, the International Center for Tropical Agriculture

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[7] www.fews.net

(CIAT) and the International Center for Maize and Wheat Improvement (CIMMYT) in Central America in a project titled “Tortillas on the Roaster” (Eitzinger et al., 2012). Developing an integrated assessment framework led to the identification of three major types of interventions (see Box 3) and the ability to target these to specific geographic locations (see Figure 9).

Box 3: “Tortillas on the Roaster”

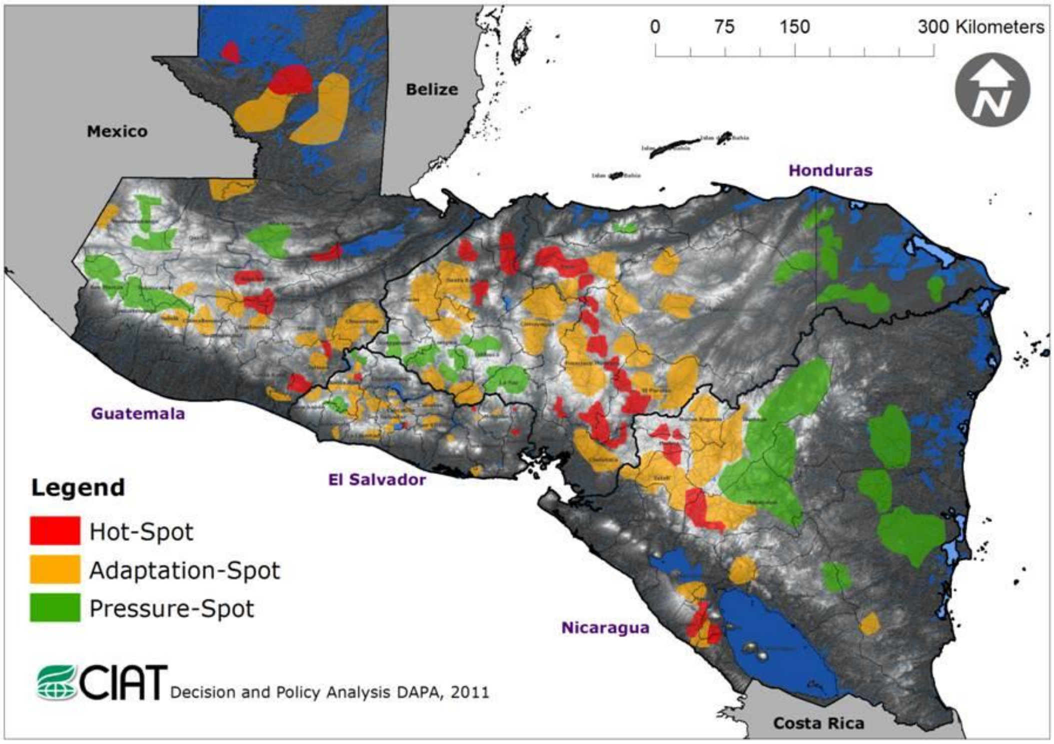
Adaptation spots: Areas of a country where yield reductions of the crops in the model, in this case maize and beans, are expected to be 25 and 50 percent by the 2020s and 2050s, respectively. In adaptation spots, EAS for agriculture can be used to promote locally appropriate adaptation practices.

Hot spots: Areas where yield reductions of the crops analyzed in the model are expected to be greater than 50 percent by 2050. In hot spots, EAS would support diversification of livelihoods and transitioning out of current, vulnerable livelihood systems.

Pressure spots: Areas with potential for 25 percent or more gains in production. The problem is that most of these pressure spots are forested or protected areas at risk of incursion by agriculture. Pressure spot interventions require support from EAS for natural resource protection and sustainable management, and offer potential targets for PES (payment for environmental services) interventions.

One of the outcomes of this effort was the predicted effect of climate change on Central American maize and bean production based on soil quality. The ability to identify and target geographically affected areas is immensely valuable to EAS programming. Using a sandy soil as a proxy for an infertile soil and a loam as a proxy for a fertile soil, the model estimated maize production losses due to climate change in El Salvador at 32.2 percent in the 2020s and 33.5 percent in 2050s when maize is grown on a poor soil. In areas with fertile soils, estimated maize yields decreased by only 1.1 percent in the 2020s and 1.8 percent in the 2050s. The model projected that most of the reduction in maize yields, regardless of soil quality, would occur over the near term. The same estimates were calculated for beans, and although there were differences due to soil type, the gap was much smaller, presumably because of beans’ nitrogen-fixing capacity. This type of information, to the extent that it is accurate, can be immensely valuable in geographic and technical targeting of EAS programming.

Figure 9. Climate change impact on bean-producing areas in Central America



Note: See Box 3 for definitions of adaptation spot, hot spot and pressure spot.

Other information and communication technology (ICT) tools are equally valuable. Weather information and the use of radio and push-type text messaging services (short message service, or SMS) have the potential to assist farmers in accessing real-time information for intra-seasonal management decisions. Early warning systems, such as the USAID FEWS NET mentioned earlier and the United Nations Food and Agriculture Organization (FAO) Global Information Early Warning System (GIEWS), will become increasingly valuable tools for national decision-makers, donors and emergency response agencies in gaining the lead time necessary to prepare response measures for slow-onset emergencies. For populations at risk, warning systems focused on acute rapid-onset threats, such as flood and typhoon warning systems in place and under development in South and Southeast Asia, will save thousands of lives. In combination, the analytic power, communication reach and immediacy of these ICT tools will become increasingly important.

Importance of policies

A review of literature suggests that few national EAS programs have launched initiatives aimed specifically at assisting farmers in adapting to climate change. It is unclear whether this is an indication that conditions have not yet reached a management switching point where change is required, an indication of the time lag in accepting, understanding and preparing responsive measures by EAS programs, or simply confirmation that many of the early adaptive responses are not sufficiently different from many ongoing development interventions targeting natural resource-dependent smallholder farmers and thus are not being recognized for their climate change adaptive qualities. This is one of many areas that warrants further investigation.

At the policy level, however, there are growing indications of positive changes taking place within national investment plans that begin to address large-scale climate change adaptations. The *Plan Maroc Vert* (the Moroccan Green Plan) is one such example; another is the Malawi Greenbelt Initiative. Cast in terms of an economic growth and poverty reduction strategy, *Plan Maroc Vert* responds to a steady 30-year decline in rainfall levels by, among other things, assisting smallholder producers to transition from hillside annual crop production to higher value tree production (principally olives, but also almonds and figs). Accompanied by investments in soil erosion structures, terraces and rock walls, plantations of trees tolerant of increasingly arid conditions will help farmers maintain and improve their livelihoods in the face of environmental change. The US$ 300 million investment under the U.S. Millennium Challenge Corporation (MCC) Moroccan compact, supporting the establishment and rehabilitation of 120,000 hectares of hillside agroforestry plantations, is one of the first major investments in implementing *Plan Maroc Vert*, to which other donors are also now contributing (Cooper et al., 2013).

In a similar fashion, the Malawi Greenbelt Initiative, with an initial politically stated target of bringing 1 million hectares under irrigation and strategic plans for developing 228,000 hectares (Government of Malawi, 2010), is primarily justified as an economic development effort aimed at exploiting the surface water resources to increase high-value agricultural production and strengthen domestic food security. By bringing a vast land base under irrigation, the initiative, if implemented, stands to make major strides in assisting producers in targeted area to transition to systems less exposed to the immediate risks of climate change.

These examples illustrate the type of policy decisions and the level of investments that governments will need to make in preparing for anticipated climate change impacts. Such plans must also include investments in EAS training programs and other support services to maximize benefits. To support implementation of *Plan Maroc Vert*, the Moroccan government has drafted a new national extension strategy. The Malawi Greenbelt Initiative called for the training of an additional 1000 extension agents, with strategic plans for hiring an additional 400 staff members over four years (Government of Malawi, 2010). The sheer size of these undertakings and the need to mobilize internal and donor resources are such that planning horizons must also be lengthened from traditional three- to five-year project cycles to 10- to 15-year and even longer investment cycles.

The reality that farmers farm the policy environment as much as they farm their fields cannot be ignored. As intended, agricultural policies involving subsidies can have a significant effect on farmer behavior. Decision-makers will need to review their policy frameworks closely with an eye to climate change adaptation to eliminate inconsistencies and identify leverage points. In Morocco and Malawi, national subsidy policies promoting grain production to increase domestic food security and reduce reliance on increasingly expensive and volatile import markets (soft wheat and maize, respectively) work against extension efforts in those countries to assist farmers to transition to more diverse, resilient production systems. The situation is particularly acute in Malawi, where 90 percent of the agricultural land is reportedly under maize cultivation. In 2011/2012, the Farm Input Subsidy Program (FISP), providing input and hybrid seed subsidies for maize production, was allocated 21 billion kwacha (165 kwacha = US$1); 5 billion kwacha was budgeted for agricultural research and extension, and the chief task of the national extension program was implementation of the FISP (Simpson et al., 2012). One effect of Malawi's input subsidies and price support policies on farmer decision-making and the private sector is to actually increase farmer exposure to risk and make them more vulnerable to climate change trends and shocks (e.g., Chinsinga et al., 2011). Increasingly, policy-makers are turning to crop insurance schemes to help dampen the impact of risks associated with intensification efforts. Such schemes, however, face implementation problems (e.g., verification of crop planting, determination of crop failure, payout mechanisms), and rising levels of climate risks may ultimately make them unaffordable.

Policy changes can also have dramatic effect in terms of facilitating farmer investments in NRM. There is perhaps no better example than that of reforestation in Niger (Stickler, 2012). As in other West African counties, Niger's post-independence Forest Code maintained state control over classified forest areas and established a list of protected species irrespective of where the trees were located (Boffa, 1999). The forestry service manned checkpoints and issued fines for the felling of trees and collection of fuel wood and tree products without permits. Understandably, most farmers viewed trees as a potential liability, and secretive tree clearing turned the country's limited agricultural lands into a barren moonscape. Uptake of farmer-managed natural regeneration practices, promoted by extension efforts beginning in the early 1980s, soared with the promulgation of a new Forest Code in 2004 that recognized customary resource rights and the right to collect and use forest products. The pace of change was accelerated through the mounting of extensive local information campaigns supported by USAID explaining the rule changes and changing the forest service from a paramilitary unit to a service department. The granting of secure tenure rights, removal of punitive fines and addition of a new source of technical assistance resulted in one of the most dramatic transformations of land cover in the region, with 5 million hectares, nearly half of the country's agricultural land, being converted to agroforestry management systems in less than a decade (Stickler, 2012). In the process, farmers greatly increased their resilience to climate change impacts.

Best Prospects: Extension and Advisory Services under the "New Normal"

The future of agriculture under the new normal is defined by increasing risks and uncertainties. The ideas presented here are intended to focus attention on key issues, stimulate thinking and identify directions for future action. Some ideas are based on what we know and have observed in the past; others are speculative best-prospect responses to a non-analog future. All are intended to urge interventions that are appropriately paced and scaled. In responding to the urgency for making progress in climate change mitigation and adaptation, and for decreasing vulnerability and increasing resilience within the agricultural sector, EAS will need to:

- identify relevant climate change risks, their geographic zones of influence and likely trajectories of onset;
- assess vulnerability and resilience of affected human and natural resource systems; and
- match appropriate actions at the requisite scales and locations and plan for the temporal sequencing of responses.

Recommendations for EAS providers:

1. EAS programs need to be well informed about the nature of climate change risks to which their coverage areas and target populations are likely to be exposed, including the relative magnitude, level of certainty, geographic location of slow- and rapid-onset risks, and likely timing of climate change impacts.
2. Within the target locations for various types of risk, EAS providers must assess the vulnerability and resilience of human populations and natural resource systems in order to prioritize the allocation of programmatic resources. Use of a systems approach to identify linkages – involving at a minimum human/social, climate/environmental, financial/food security dimensions – is critical.
3. On the basis of assessed needs, EAS programs must identify responses that capitalize on multi-win, no-regret and robust options, where these exist, demanding in turn that research institutions begin the hard work of assessing and screening available technologies for their fit under likely future conditions, and identify technology gaps now so that appropriate responses will be available when they are needed. Issues that need to be taken into account by EAS programs include how to:
    a. properly fit/scale interventions;
    b. determine social/organizational requirements to support technical choices;
    c. develop market and non-market incentives for farmers and other stakeholders to stimulate behavior change; and
    d. mediate potential policy distortions that may increase smallholder risk.
4. To identify potential technical and social alternatives, EAS providers must establish and aggressively engage in national platforms for networking and exchange of experiences, participate in subregional forums and become skilled in tapping into cross-regional and global resources. At the field level, learning from and building upon indigenous responses will be particularly challenging but vital.
5. To be successful, technology transfer efforts need to be accompanied by streamlined procedures for technology release combined with the freedom to actively encourage and facilitate experimentation with new technologies by contact farmer groups.
6. EAS providers should participate in the identification and use of ICT applications for various target audiences – early warning systems for policy-makers, weather information for farmers, emergency alert systems (e.g., floods) for populations at risk.

7. Pre-service education and in-service training programs will need to be significantly upgraded, if not completely overhauled, to prepare and update field and management staff members on the realities they may face under evolving climate change conditions. Critical areas include a sound understanding of climate change dynamics, a broad systems orientation, technical competency and methodological expertise.
8. EAS program directors will need to increase their contribution to policy formation and, when offered the opportunity, review draft policy proposals for their implications for climate change adaptation and the risks that producer populations may be subjected to. Policy-makers must prioritize investments in EAS programs and related support services as their best tools in helping farmers to make difficult transitions in the years to come.
9. Organizational reviews will need to be undertaken to identify and remove programmatic divides between ministries, and harmonize and capitalize on potential operational synergies among EAS programs (e.g., crops, forestry, livestock, etc.). National EAS programs must actively seek collaboration with actors outside of government who can multiply EAS impacts at farm and landscape levels at scales hitherto only aspired to.
10. Perhaps most challenging of all will be efforts to bring field-level coordination and coherence to public- and donor-funded initiatives, and to help orient private-sector actors to emerging climate change adaptive opportunities. Coalitions of public- and private-sector actors with donors and NGOs working to design and implement national strategies are called for.

The list of needs is long and the demands are high, but the stakes are higher still. All those involved will be challenged to elevate their efforts. Our continued ability to feed the planet depends on the outcome.

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