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Adaptation under the New Normal of Climate Change: The Future of Agricultural Extension and Advisory Services

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Introduction

Adapting to climate change is the most serious challenge facing our species. The scale is global, trajectory of onset uncertain and impacts potentially catastrophic (IPCC, 2013). As further evidence emerges and 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.

Extension and advisory service (EAS) providers have a key role to play as a critical link between farming populations and sources of new information and tools, so that practices can be appropriately adapted.

This brief outlines the challenge of adapting to climate change, identifies past and present points of EAS engagement, and proposes future responses, with a focus on the constraints and conditions of smallholder farmers in the tropics, and the natural resource base upon which agriculture depends.

Box 1: Definitions of key terms used in this brief 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).
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…" (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…" (IPCC, 2012).
Mitigation:	The efforts undertaken to "reduce anthropogenic [greenhouse gas] emissions or to enhance natural sinks of greenhouse gases" (IPCC, 2007b).

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The “New Normal” – the central biophysical forces

Before they can prepare for and respond to global climate change, **EAS providers must first understand the nature of climate change, the associated challenges and potential impacts**. The rapid 20–25% downturn in precipitation across the West African Sahel that happened around 1970 and lasted through the 1990s provided a glimpse of what the future may hold. Global climate change, however, is unlikely to produce such a sudden change.

Climate change is a gradual process that will continue well into the next century with impacts felt over the next millennium. Climate change is also non-linear and highly complex, with layers of feedback loops and unknown “tipping-points” that, when exceeded, offer no retreat. Moreover, changes will continue on multiple fronts – air temperature and amounts and patterns of precipitation, as well as other weather features. Climate change should also be understood as permanent; there will be no return to prior conditions over the course of individual human lifetimes (IPCC, 2013).

Climate change will exert increasing pressure on a complex web of relationships among social, environmental, economic and food systems. This will affect our ability to meet other major challenges, especially feeding the world’s growing population, which is expected to reach 9.6 billion by 2050 (UNDESA, 2013). The environmental impacts of meeting rising food demand will intensify as global warming and associated climate changes accelerate the degradation of vulnerable, overburdened environments. In response **EAS providers must be able to assess the vulnerability and resilience** of human populations and natural resource systems in order to prioritize the allocation of resources, **using a systems approach**. EAS providers will be challenged to contend with the effects of two dimensions of climate change: (1) **climate change trends** and (2) **weather disruption**.

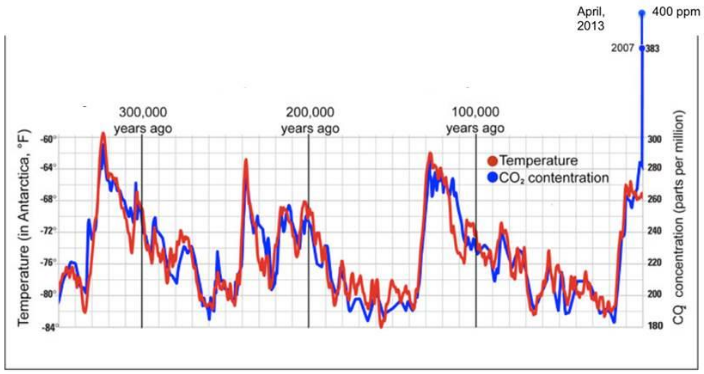
1. Climate change trends (slow-onset systemic changes)

Greenhouse gases (GHGs): Carbon dioxide (CO_2) is the primary GHG emitted through human activities, and agriculture is a significant contributor. Taken together, the deforestation and energy use associated with agriculture result in the sector being responsible for roughly one third of all GHG emissions (IPCC, 2007b). To avoid triggering significant climate change and catastrophic effects on the planet’s ecosystems, the upper limit of atmospheric CO_2 concentration is estimated to be around 350 ppm (Hansen et al., 2008). Concentrations have risen steadily over recent decades, reaching 400 ppm in May 2013. At this rate, CO_2 levels are on track with the IPCC’s most pessimistic projection for 2100 (IPCC, 2013). Even if all additional emissions were eliminated, 15–40% of the warming effect from past emissions would continue for the next 1000 years (IPCC, 2013). And we have barely begun the serious work of reducing emissions.

Global warming: Rising levels of atmospheric CO_2 lead to an increase in land and sea surface temperatures – global warming. Historical records show a close tracking of air temperatures with atmospheric CO_2 levels (see Figure 1). Over the past 60 years, average global air temperature has risen by 0.7°C; temperatures over some land areas and in high latitudes have risen by double this amount (IPCC, 2013; IPCC, 2007a).

Rising air temperatures trigger secondary effects: These include: (i) changes to seasonality, especially the onset and duration of warm seasons in northern latitudes; (ii) changes in the onset and duration of rainy seasons in the tropics; (iii) melting of polar ice caps, northern latitude ice shields and high-altitude glaciers worldwide, leading to changes in freshwater discharge and rising sea levels; and (iv) more water cycling through the climate system (since warmer air carries more moisture), but with non-uniform distribution – wet areas are projected to get wetter and dry areas drier.

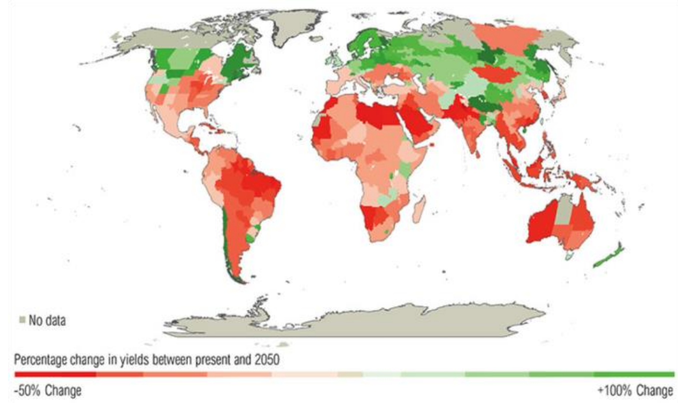
Figure 1. CO_2 and global temperatures[1]



Tertiary impacts on agriculture: These include: (i) rising air temperatures and changes in seasonality affect the timing of plant maturation during critical stages, and disrupt plant–pollinator and pest–predator relationships – the resulting yield declines will erase any positive effects on photosynthesis from higher concentrations of atmospheric CO_2 (see Figure 2); (ii) by 2100, average growing-season temperatures are projected to exceed the temperature tolerances for many crops where they are now grown; (iii) the decline and eventual loss of glacial water sources will drastically affect the systems that depend on these for irrigation; (iv) rising sea levels will inundate low-lying coastal areas and islands, causing increased saltwater intrusion in coastal river and groundwater systems, eventually displacing up to 10% 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 is unknown. But these general trends will continue as long as we continue to emit substantial amounts of GHGs, and long after. Since agriculture is a major source of emissions, this effect will likely increase as we struggle to increase food production to feed the world's growing population by the required 60–70% by 2050 (FAO, 2009; USAID, 2013).

Figure 2. Projected impact of a 3°C temperature increase on crop yields[2]



2. Weather disruption (extreme and aberrant weather events)

More frequent and severe events: Severe weather events – droughts, floods, hurricanes cyclones/typhoons and heat waves – are occurring with increased frequency, duration and severity (IPCC, 2012). The additional moisture carried by warmer air and the increased energy stored in the oceans are leading to more intense and frequent storms, as well as systemic changes to rainfall (IPCC, 2013). Extreme heat events that typically occur once in 20 years are predicted to occur every two years by 2100 (IPCC, 2012). Historically rare events (i.e., once-in-50-years or more) will become commonplace (see Figure 3). Changes are also occurring in temporal and geographic distribution of severe weather events. EAS providers will increasingly be called on to assist with relief efforts in the wake of these crises (Shepherd et al., 2013).

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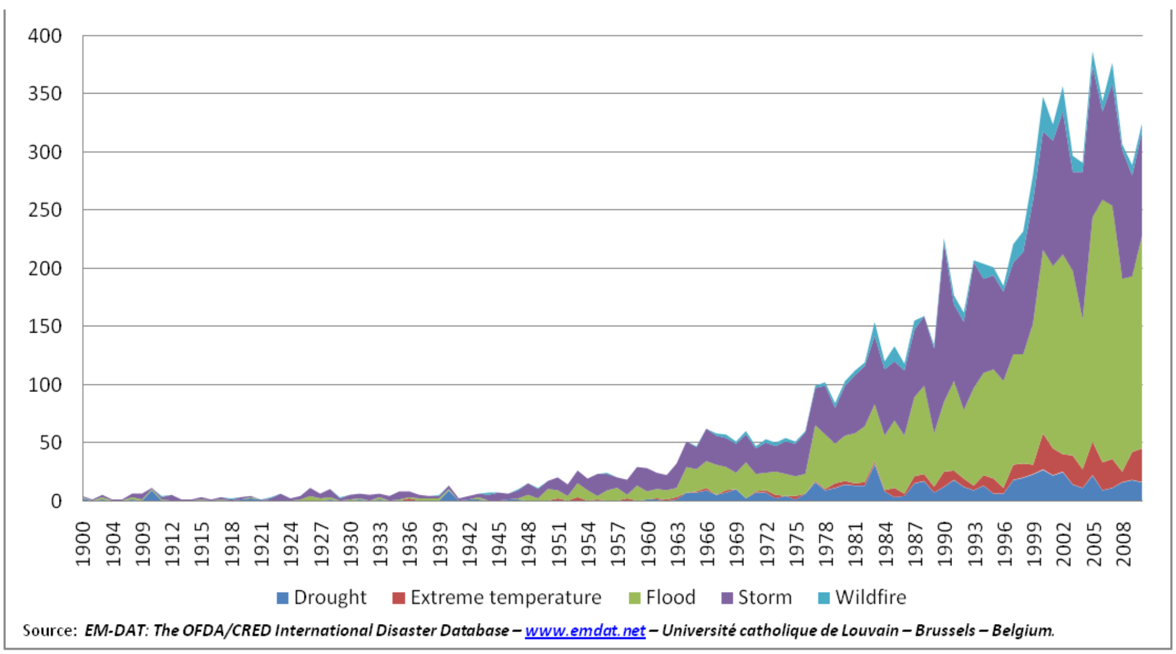
[1] *Source:* Southwest Climate Change Network, (www.southwestclimatechange.org/figures/icecore_records), modified from Marian Koshland Science Museum of the National Academy of Sciences (www.koshland-science-museum.org).

[2] *Source:* World Bank, 2010.

Depletion and reduced resilience: Weather disruption wears down the resilience of human and natural systems. Productivity will decline in some areas, and depleted natural and financial resources will mean reduced investment in long-term welfare improvements. Economies dependent on rainfed agriculture will be especially vulnerable; for example in Africa, between 1960 and 2000, gross domestic product closely tracked the rise and fall of annual rainfall (Barrios et al., 2003). At the farm level, investments in agricultural enterprises, especially those that depend on vulnerable local resources (e.g., water), will become increasingly risky. To identify potential technical and social alternatives, EAS providers must aggressively engage in national and sub-regional platforms for networking and become skilled in tapping into cross-regional and global resources. At the field level, learning from and building upon indigenous responses will be vital.

Figure 3. Numbers of extreme weather events globally, 1900–2008[3]



Implications for Smallholders and the Rural Poor

Global climate change has sobering implications for natural resource management (NRM), food production and reliance on agriculture for poverty reduction and economic growth (World Bank, 2010). In the tropics, older villagers and more experienced farmers have noted changes in climate and weather for several decades, along with pressures related to the intensification of resource extraction (Bryan et al., 2009; Ebi et al., 2011; Gbetibouo et al., 2009).

One of the hallmarks of the vitality of rural communities is their ability to adapt to changes affecting their livelihoods. But the fewer assets that rural families have – human, financial, natural, social, political, physical – the more challenging this becomes and the longer it takes to recover from even modest shocks.

[3] *Credit:* Naam, R. (2013). The infinite resource: The power of ideas on a finite planet. Lebanon, NH: University Press of New England.

Many rural households already struggle to survive as natural resources degrade. The adverse impacts of climate change trends and weather disruptions will further deplete the assets of the rural poor, increasing their vulnerability (Barrett & McPeak, 2006). In this context, the need to link individual agricultural decisions with larger landscape and land use management challenges is fundamental.

Individuals and communities can be slow to implement NRM changes, especially if there are no immediately observable benefits (Marenya & Barrett, 2007; Shiferaw et al., 2009). Often the benefits take time to manifest and can be masked by seasonal stresses. But changes in local weather patterns will eventually push smallholders to take up new practices. Indeed, disasters can trigger rapid, widespread behavioral change that EAS providers must be prepared to capitalize on (see Box 2).

Box 2: The lessons of Hurricane Mitch

The events in the aftermath of Hurricane Mitch in Central America in 1998 illustrate the importance of timing and scale. Families who previously resisted planting live contour barriers to stem runoff and erosion lost their hillside plots, while neighboring plots protected by well-spaced vetiver hedges and rock barriers were spared. A large multi-agency research project found that plots under conservation agriculture practices sustained 58–99% less damage, retained 28–38% more topsoil and suffered two to three times less surface erosion than conventionally managed plots. Households that had previously resisted NRM immediately began to demand training and to adopt “new” practices and technologies (World Neighbors, 2000).

Lesson 1: Use observable evidence of severe events to focus farmers’ attention on the importance and interrelations of NRM and agricultural management; capitalize on the teachable moments.

Lesson 2: Target behavioral change efforts at appropriate scale – e.g. here, hillsides within a watershed.

The challenges of climate change for EAS providers

With the cumulative effects of climate change, EAS providers will increasingly need to assist vulnerable rural communities to:

a. ***mitigate*** risks of further climate change by conserving carbon stocks, reducing CO_2 emissions, and helping to sequester atmospheric CO_2 in trees and soil organic matter;
b. ***adapt*** their livelihoods to changes in weather patterns, and restore natural resources; and
c. strengthen the ***resilience*** of natural and human systems to withstand and recover from shocks.

EAS Key Challenge No. 1. Determining the technological and adaptive switching points

The greatest challenge facing extension and research programs will be to help farmers and rural communities determine the timing, nature and location of specific adaptive changes. The challenge lies in helping them transition from current to anticipated future conditions, while keeping in sight the context of location-specific problems, appropriate scale and time frame, and availability of resources. To effect landscape-level changes in NRM, EAS providers will need to use multi-stakeholder decision-making processes to make hard choices, broker agreements, strengthen management structures and mediate conflicts.

Specific decisions related to climate change adaptation may include when to:

- switch to varieties and crops with greater tolerance to emerging climate change stressors;
- modify or switch land-use systems (e.g., from annual crops to mixed tree-crop systems);
- supplement rainfed production with irrigation as dry spells increase in frequency or length;

- augment the capacity of drainage systems to handle extreme rainfall events;
- migrate to cultivate different land (e.g., move from drought-prone uplands to better watered lowlands);
- diversify out of agriculture or abandon areas that are untenable as zones of production.

Making these choices will be difficult. The optimal timing for adaptive responses is never obvious, because it depends on local and external resources and costs; individual, social and institutional capabilities; evolving markets; and national policy frameworks. Individual technology and management choices will only offer benefits under specific sets of conditions, and may involve significant advance planning. Once taken, choices may preclude other pathways and offer varying degrees of robustness in their resilience to possible climate futures. And in all cases, there are limits to adaptation.

EAS Key Challenge No. 2. Enhancing effective technology exchange, adaptation and dissemination

To meet these challenges, EAS providers must enhance and facilitate technology exchange, adaptation and dissemination of practices to match the need for continual climate change adjustments. For guidance, EAS providers can learn from how others have adapted to significant changes in climatic conditions, including indigenous responses, and also draw lessons from formal research on new or best-bet responses to projected conditions. The ability to skillfully identify and efficiently assess, modify, test and exchange useful technologies and practices from around the world will be increasingly important as research systems struggle to keep pace with new and evolving problems (e.g., Ramírez-Villegas et al., 2011). Without a unified global agricultural knowledge system, we are collectively ill-prepared to utilize the wealth of agricultural knowledge generated over the course of human history.

Technology transfer efforts need to be accompanied by streamlined procedures for technology release combined with on-farm experimentation of new technologies by farmer groups.

EAS providers – bringing it all together

It will be imperative for EAS providers to step fully into a facilitating role; there is yet, however, no comprehensive set of tools and tested practices to help farmers implement the necessary climate-related adaptations. 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 can be viewed as "no-risk" or "no-regrets" (Heltberg et al., 2009) – i.e., changes that will strengthen overall resilience and enhance productivity regardless of whether anticipated climate-induced shocks materialize or not.

The challenges of climate change call for stronger integration of NRM and agricultural EAS (Hunt et al., 2011; Johnson et al., 2006). However, few public-sector extension systems are structured to facilitate this integration. One exception is Malawi, where the same public-sector extension field agents support the full range of crop, livestock, fisheries, forestry and irrigation programs. The downside, however, is that the variety of demands placed on individual field agents far exceed their training and programmatic support (Simpson et al., 2012).

EAS providers will also need to manage local opinion to avoid panic and destructive short-term behaviors, and to address the despondency of indigenous populations losing a sense of place. Engendering trust and credibility with local populations will be key. All in all, frontline EAS providers will need to dramatically increase their knowledge and skills to prepare for life under the new normal.

The Road Ahead

The approximately 2.5 billion smallholder farmers (IFAD, 2013) who manage nearly 22.2 million km^2 of the earth's surface (Zomer et al., 2009) represent a tremendous force in the effort to utilize NRM practices to help mitigate GHG emissions. Agriculture is also looked to as an engine for economic growth, poverty reduction, increased food security – all predicated on effecting widespread behavioral change involving the adoption of more productive, less wasteful agricultural technologies and management practices. Working with farmers and the rural poor to achieve these objectives under adaptation to the new normal – a context of continual and increasingly disruptive change – is a daunting challenge. EAS providers will first need to help farmers understand that responses demand truly adaptive measures and not simply belt-tightening and coping; conditions will not return to the way they used to be.

To respond to the breadth of adaptation challenges, EAS providers will need to implement the following five approaches:

(i) Modify strategies and operational frameworks for engaging rural populations

Global climate change will require a return to the use of systems thinking. However, under the new normal, the process of continuous change will not allow time for in-depth investigations of system interactions. Instead, systems-based research and EAS will need to engage broad-based system principles that hold over a wider range of conditions. Fortunately, within the domain of NRM-oriented agriculture, many land management principles confer broad-based, systemic benefits that allow farmers to contribute simultaneously to mitigation efforts while making needed adaptations and enhancing the resilience and profitability of their livelihoods. Basic principles relating to soil organic matter management, protection of critical water sources, and competitive and facilitative plant production interactions can be applied by farmers – in endless configurations – across a range of climate regimes. Many of these principles, as well as complementary methods of involving farmers in research, will become an increasingly valuable resource.

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, such as the new heat-, drought- and flood-tolerant crop varieties being developed by international agricultural research centers. 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. The need to rely on and feed farmers' innovative and adaptive capacities will be an integral part of EAS operational strategies.

(ii) Work with groups of people at appropriate scales

EAS providers will usually need to engage in iterative cycles of experimentation and learning as they begin to work with rural communities in testing high-potential innovative adaptation practices while risks are low. In most contexts, the optimal entry point will be selection of "no-regrets" strategies.

Despite the challenges, strengthening social capital for collective action and strengthening the local knowledge base on local ecosystem functioning are essential parts of a climate change adaptation strategy. In general, the rural poor have a deep attachment to the areas where they live and their collective environmental knowledge is an important asset for managing local natural resources. Ferse et al. (2010) found that community involvement in environmental design for access, use and protection of natural resources resulted in more adaptable and flexible management, as well as 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 in new perspectives and opportunities that helped to increase resilience through adaptive management (Bodin et al., 2006).

(iii) Overhaul EAS education and training curricula

EAS education and training programs must be significantly upgraded so that field and management staff members are prepared for the risks of climate change. After decades of neglect, pre-service (college-level) education programs need a major overhaul, and regular in-service updates need to be added. There is a worldwide human resource crisis in agriculture. EAS assessments carried out by the MEAS project have found that that the population of public-sector EAS staff is aging; the average staff member is within a decade of retirement (e.g., Simpson et al., 2012). The gaps that will be created by retirement, combined with the current gaps and weaknesses in the EAS education and training system (Simpson & Singh, 2013) will exert themselves for years to come, just when the need for a larger, more capable EAS workforce is becoming urgent. Donors and national governments must invest in education now, to revitalize national training programs that will prepare a new generation of EAS practitioners for the challenges of responding to conditions under the new normal.

(iv) Maximize use of advanced information and communications technology (ICT)

The potential applications of advanced technologies to aid sustainable development have been promoted for over two decades. Beyond the research community, however, little progress has been made in their utilization. In contrast, USAID's Famine Early Warning System Network (FEWS NET), operating since 1985, will likely see increased use in the decades ahead. 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 staff in directing their efforts.

One example of combining the predictive capability of climate and crop modeling with soil and geographic data is the "Tortillas on the Roaster" project (Eitzinger et al., 2012). An integrated assessment framework led to identification of three major types of intervention best suited to specific geographic locations (see Box 4 and Figure 4). One result of this project was the capability to predict the effect of climate change on maize and bean production by location, showing that improved soil quality will be vital to adaptation of many crops. This type of information can be immensely valuable in geographic and technical targeting of EAS programming.

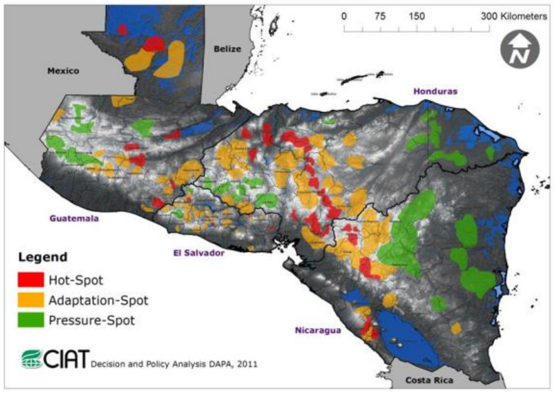
Box 4: Three major types of interventions identified by the "Tortillas on the Roaster" project

Adaptation spots are areas where yield reductions of the crops in the model, in this case maize and beans, are expected to be 25–50% by the 2020s, or by the 2050s at the latest. Here, EAS for agriculture can be used to *promote locally appropriate adaptation practices*.

Hot spots are areas where yield reductions of the crops in the model are expected to be >50% by 2050. Here, EAS would support *diversification of livelihoods and transitioning out of current, vulnerable livelihood systems*.

Pressure spots are areas with potential for ≥25% increases in production. The problem is that most of these areas are forested or protected, and are at risk from incursion by agriculture. Interventions here require support from EAS for *natural resource protection and sustainable management*, and offer potential locations for PES (payment for environmental services).

Figure 4. Climate change impact on bean-producing areas in Central America



Other ICT tools are equally valuable. Weather information and the use of radio and text messaging services have the potential to assist farmers in accessing real-time information to help with intra-seasonal management decisions. Early warning systems, such as FEWS NET and the United Nations Food and Agriculture Organization's Global Information Early Warning System, will become increasingly valuable, providing national decision-makers, donors and emergency response agencies with the lead time necessary to respond to slow-onset emergencies. For populations at risk, warning systems focused on rapid-onset emergencies, such as floods and typhoons, are in place and under development. The analytic power, reach and immediacy of these ICT tools will become increasingly important.

(v) Advocate for supportive policies and institutional frameworks

At the policy level, some countries have begun to integrate large-scale climate change adaptations into their national investment plans. The *Plan Maroc Vert* (the Green Morocco Plan) is one example. The Plan responds to a 30-year decline in rainfall by, among other things, assisting smallholder producers to transition from hillside annual crops to higher value tree production – especially olives, almonds and figs, which are tolerant of more arid conditions. Among other donors, the U.S. Millennium Challenge Corporation has invested US$ 300 million to support the establishment and rehabilitation of 120,000 hectares of hillside agroforestry plantations.

Another example is the Malawi Greenbelt Initiative, with an initial target of bringing 1 million hectares under irrigation and plans for developing 228,000 hectares (Government of Malawi, 2010). The initiative is primarily justified as an economic development effort aimed at exploiting surface water resources to increase high-value agricultural production and strengthen food security. The initiative will assist thousands of producers to transition to systems less exposed to the immediate risks of climate change.

These examples illustrate the types of policy decisions and the level of investment that governments must make to prepare for anticipated climate change impacts. Both initiatives have included investments in EAS training programs and other support services in their plans. The sheer size of these undertakings are such that planning and investment cycles must be lengthened to 10 or 15 years or more.

Agricultural subsidies to promote grain production are designed to influence farmer behavior. These policies, however, can work against efforts to help farmers transition to more diverse, resilient production systems, leaving them more vulnerable to shocks (Chinsinga et al., 2011). EAS program directors will need to engage more intensively in policy formation and review, and policy-makers must prioritize investments in EAS programs and related support services to help farmers make difficult transitions. Relatedly, the institutional frameworks that result in programmatic divides between ministries must be removed to capitalize on operational synergies among EAS programs (e.g., crops, forestry, livestock, natural resources).

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. The design and implementation of effective national strategies will demand the involvement of coalitions of public- and private-sector and non-profit actors.

Conclusion

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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