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Amplifying impacts of DOE research: Enhancing the sustainability of agricultural landscapes in developing nations

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ORNL shares and applies the lessons learned from DOE-funded sustainability research with collaborators working in agricultural communities in developing nations around the globe. In Guatemala, as reported in Nature Sustainability, the team finds that targeted technical assistance can complement and build upon indigenous knowledge to improve livelihoods. Working with local researchers, extension agents and community leaders in villages of northwest Guatemala, disease-resistant climbing beans and technical assistance are found to enhance the productivity and nutritional value of traditional mixed-crop systems, thereby reducing hunger, poverty and pressures to migrate. The ORNL Strategic Partnership Project with the International Center for Maize and Wheat Improvement (CIMMYT) in Mexico, applied stakeholder engagement methods (Dale et al. 2019) with researchers and farmers in the Yaqui Valley, Mexico (Eichler et al. in review), and the western highlands of Guatemala (Kline et al. 2020) to identify and prioritize opportunities to increase the sustainability of agricultural landscapes.

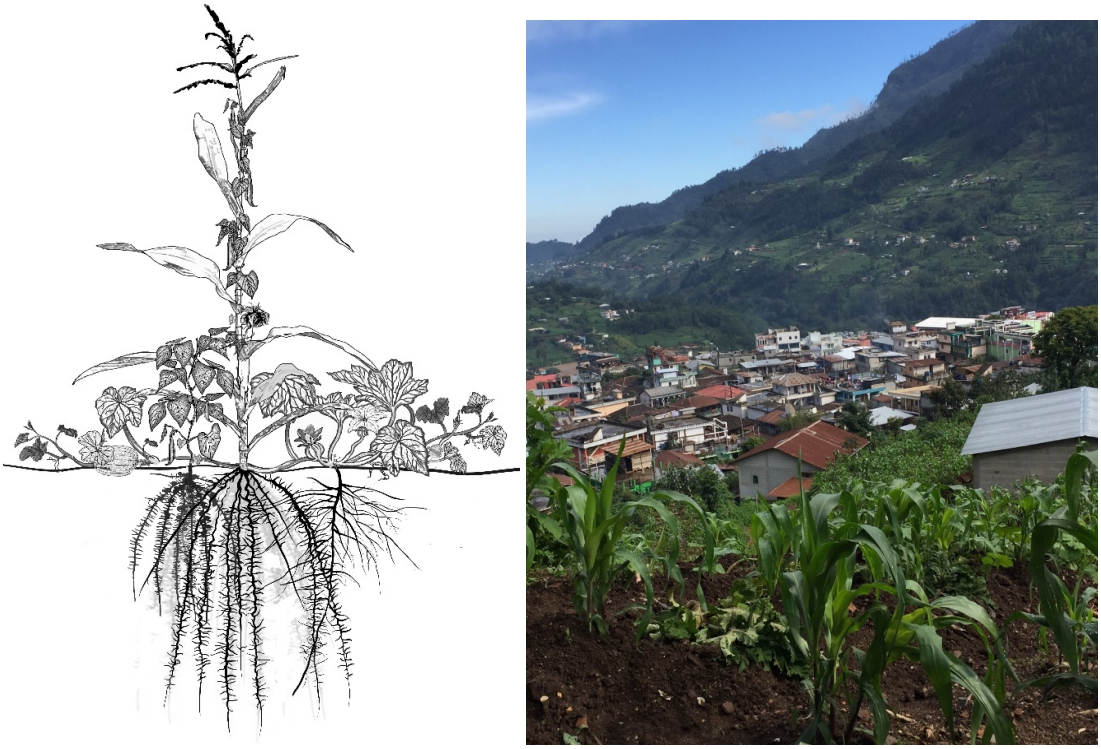
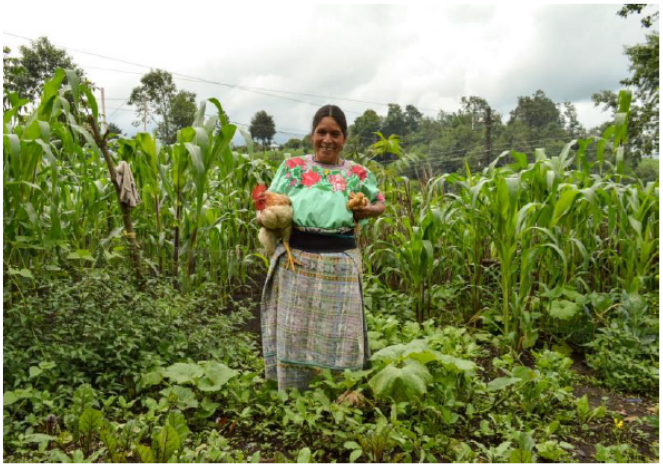


FIG 1: Highland maize production is based on the *milpa* system in which small agricultural plots of maize together with climbing beans (*Phaseolus* spp.) are mixed with a variety of squash (*Cucurbita pepo*) and other crops. Maize plants provide the structural support for the climbing beans; while beans enrich soils via symbiotic association with nitrogen-fixing bacteria and provide essential dietary protein that complements maize. Squash and other crops protect the soil surface from erosion, decrease water losses through evaporation, and limit weed pressure [Drawing CIMMYT; Photo: K. Kline, ORNL].

Multiple benefits of *milpa* systems in the Guatemalan Highlands.

Practices:
- Mixed crop associations
- Rotations
- Fallow periods
- Organic fertilizer
- Crop residues managed without burning
- Integrated pest management pre- and post-harvest
- Crop varieties selected for local conditions



Socio-economic benefits:
- Food security & nutrition
- Community networks
- Reduce reliance on external income
- Conservation of cultural identity
- Increase jobs, welfare & stability

Environmental benefits:
- Soil enhancement
- Pest & disease control
- Water quality & regulation of runoff

Strengths of indigenous culture:
- Knowledge about *milpa* systems
- Work ethics
- Family traditions & community customs
- Conserving aesthetic value of diverse, mixed-use landscapes

Scientific contributions
- Monitor, evaluate, train trainers, & share new knowledge
- Broker public-private-community partnerships
- Develop disease-resistant seed varieties adapted to local needs and preferences
- Facilitate local entrepreneurs as seed producers
- Link researchers, producers, consumers & policy-makers

FIG 2: A *Buena Milpa* demonstration plot in the Western Highlands of Guatemala exemplifies the diversity 15 of products and benefits that can be produced on small plots including maize, beans, squash, vegetables, salad greens, herbs, and chickens [photo: Buena Milpa Project, CIMMYT].

ORNL's research collaborations with CIMMYT are highlighted in the February Nature-Sustainability Comment (Vol.3(2) 74-76). Results from the CIMMYT-ORNL Strategic Partnership are being synthesized in a special issue of the journal Futures, and to strengthen integration of sustainability science into CIMMYT's efforts to generate results that improve livelihoods, health, and system resilience.

CIMMYT works with 800 counterparts in over 100 nations around the world (CIMMYT 2019). The ORNL Strategic Partnership with CIMMYT was funded by the US Agency for International Development (USAID) and supported by the Smith Center for International Sustainable Agriculture, University of Tennessee, Knoxville.

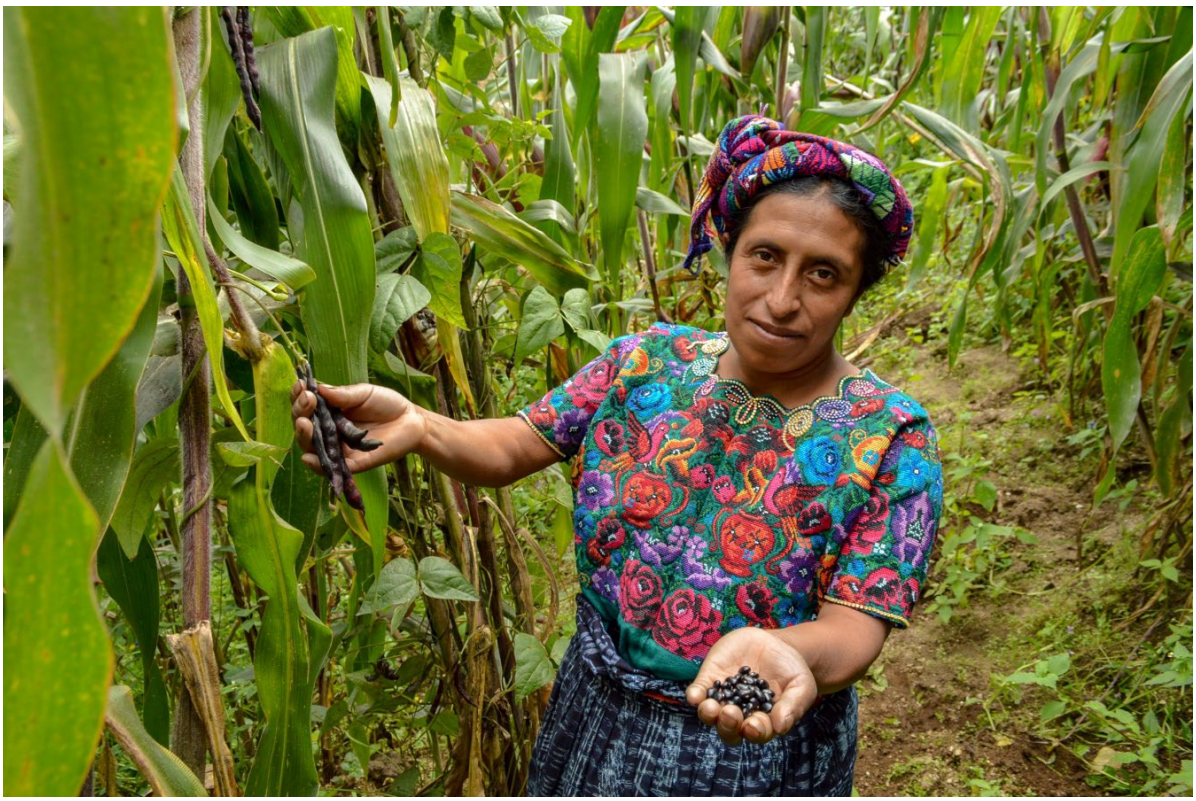


FIG 3: Farmer showing beans raised in *milpa* system in the Highlands of Guatemala. Preferred bean varieties in the Highlands reflect tradeoffs among yield, aggressiveness, culinary preferences, and longevity of food availability based on input from farmers and consumers. Social acceptance is key to enabling widespread adoption, which creates demand and leads to local 15 opportunities for jobs in seed production and distribution, extension, and pest control [photo credit: Buena Milpa Project, CIMMYT].

Key points

- Applied stakeholder engagement approach process (Dale et al. 2019) in the assessment process helps build capacity
- To tackle hunger and poverty in the Guatemalan Highlands, technical assistance should build upon indigenous farming knowledge and include women (Lopez-Ridaura et al. 2019).
- Mixed-crop milpa systems have been used for thousands of years. Enhancing these systems could reduce hunger, poverty and pressures to migrate (Kline et al. 2020).
- Engaging stakeholders is important for more sustainable reductions in rates of malnutrition and infant mortality in rural areas (CIMMYT Buena Milpa project).
- Can enhancing indigenous agricultural systems improve food security and reduce pressures to migrate? Research suggests it can help but complementary investments are also required (Kline et al. 2020).

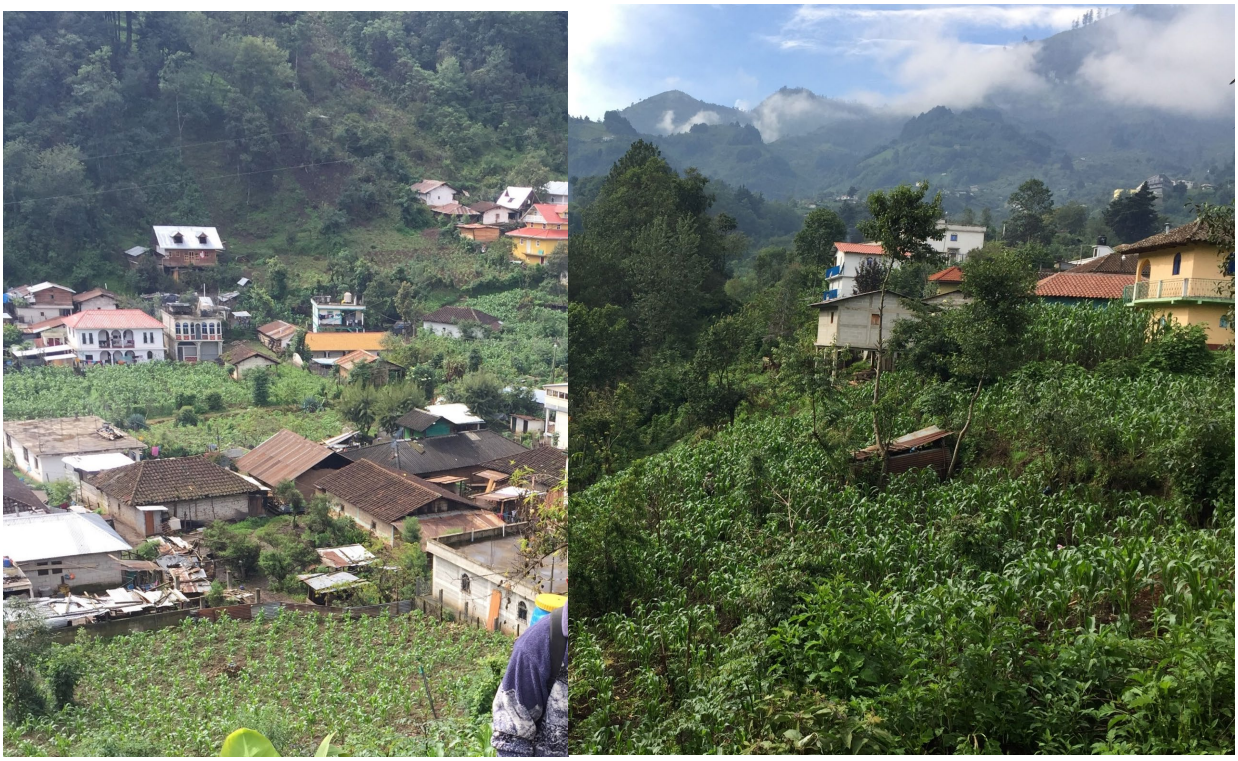


FIG 4. In steep valleys of the Western Highlands, maize-dominated family plots and gardens occupy every unclaimed space [Photos: K. Kline, ORNL].

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*forthcoming in *Futures:* Dale, Kline, Lopez-Ridaura, Eichler, Ramirez, Ortiz-Monasterioa Towards Sustainable Landscapes - Lessons learned from contrasting rural agricultural systems.