

THE DILEMMA OF AFRICAN AGROBIODIVERSITY: ETHIOPIA AND THE ROLE OF FOOD INSECURITY IN CONSERVATION

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Abstract

*Landrace (or *in situ*) varieties of important crop species are becoming increasingly important to global agriculture as gene banks have increasing trouble keeping pace with the need for genetic material for plant breeders. However genetic erosion (or permanent loss of genetically diverse landrace varieties) poses significant threat to the viability of important genetic material. Processes associated with food insecurity are thought to separate farming communities from agricultural systems in which landrace varieties are important components. While such processes are thought to operate in similar fashion across different cultural ecologies to erode the presence of genetic material, this paper presents evidence from highland Ethiopia in which many of these same processes operate in reverse to instead conserve agrobiodiversity. However conservation of such landrace varieties in this way presents a particular and problematic dilemma to which straightforward answers remain elusive.*

Introduction

Global food supply rests precariously on a small number of crop species. Approximately 95 percent of the dietary energy provided to humans come from only 30 crops that "feed the world" (FAO 2000). Sub regionally this number increases but is still relatively small (FAO 2000). But as these crops are modified to produce more food, their genetic base narrows and they become increasingly vulnerable to devastations caused by climate variations, pests, and disease. And climate change brings with it much in the way of unpredictability for agriculture as new niches for disease and pests are created and climate variability increases.

The traditional approach to deal with the dangers of large scale crop failure due to drought, disease, and pest impacts, is to utilize genetic material contained in varieties of relevant species that have not been modified, in order to locate the genetic abilities that allow the plant to be resistant to specific problems. While gene banks have been popular for some time as a repository for much of this material, there is significant concern that such banks only capture 'snapshots' of genetic material that, once 'banked' are unable to express new forms which result from adaptation to changing environments and conditions, and the emerging pests and diseases which these produce. As a result significant attention is currently being placed on 'landrace' varieties of genetically diverse crop species which continue to exist in agricultural systems in specific locations of the world, and are thus able to continue to adapt to changing circumstances and environments. Such landrace locations of crop species thus provide a 'service' to the

viability of global food supply in that they act as living repositories for genetic material valuable to future modifications of important food producing plant species.

However significant evidence exists indicating that many important locations of landrace plant varieties are under threat due to a number of processes that result in the separation of agricultural populations from land and agriculture. The resulting 'genetic erosion' is thought to seriously threaten the future viability of global food supply, due to the loss of valuable genetic material (Fowler and Mooney 1990; Madeley 1996; Tripp and van der Heide 1996; Tuxill 1999).

The processes operative in genetic erosion are those which involve problems of food security. They include famine, drought, flooding, replacement of traditional crop varieties with higher producing hybrids, poverty, conflict, land degradation, and food aid (Hutchinson and Weiss 1999; Egziabher 1991; Chitrakon et al 1999). An important assumption with genetic erosion is that the component processes occur in basically the same way across all cultural ecologies--resulting in loss of genetic material--albeit with varying rates and conditions (see discussion by Zimmer 1992). This paper presents evidence from highland Ethiopia, (long known as a center for crop genetic diversity) where several important processes thought broadly to cause genetic erosion, actually intersect with the particular cultural ecology of the highlands, to instead act in reverse to conserve genetically diverse local varieties of important crop species in a 'reservoir' effect. Fieldwork was undertaken in Ethiopia over the course of 1999, while the author served as Country Representative to the American government's Famine Early Warning System (FEWS). Food insecurity in Ethiopia in 1999 was widely regarded as the most problematic year in the country since the 1984/85 famine (UNDP-EUE 2000). Thus 1999 allowed a look at a number of the processes thought to be the primary causes of genetic erosion.

Ethiopian Agrobiodiversity

Highland Ethiopia is the center of genetic diversity for a number of important crop species, among them: barley, durum wheat, sorghum, linseed, finger millet, chick pea, cow pea, niger seed, arabica coffee, tef, ensete, and oats. While not all of these crops are originally from Ethiopia, their arrival to the highlands and subsequent cultivation in varying microclimates over the millennia have resulted in a pronounced diversification into varieties that do not exist in their areas of origin. Crop species diversity in the highlands has come to exist in part for reasons similar to other highland locations--highly dissected terrain inhabited by agriculturalists for very long periods of time, allowing for crop species to be subjected to varying microclimates and agricultural conditions (Egziabher 1991; Zimmer 1992).

Processes of Genetic Erosion in Reverse:

Landrace Conservation in Highland Ethiopia

Agriculture in the highlands

Climate variability, and particularly drought in Ethiopia, and the subsequent food insecurity, impacts on highland agriculture with a frequency and severity that has made the country the textbook example of the climate – agriculture – food shortage nexus. While drought has particular influence on food insecurity, flooding, frost, hail and variations in seasonality also significantly affect agriculture, particularly when human vulnerability is high, causing small variations in climate to have relatively greater effect.

Agriculture in highland Ethiopia (Figure 1) has several central features. Due to the very long periods of agricultural occupation, the highlands are heavily populated. High population densities together with customary land tenure arrangements that provide for dividing holdings between offspring, means that land fragmentation and the resulting very small field sizes prevail over very large areas. Thus significant parts of the highlands resemble a vast patchwork of contiguous, irregularly shaped very small fields (Figure 2). Such small field sizes (frequently less than a hectare) do not produce an abundance of food, such that food insecurity of varying degrees for the highland population is also a prevailing feature. It is this context of very small plot size, high population density, and a high frequency of severe agricultural problems that provides the food insecurity context in which issues of genetic erosion or conservation operate in highland Ethiopia.

In a genetic erosion context, an important question for Ethiopia is, with drought and the resulting food insecurity some of the more powerful forces in the erosion of crop genetic diversity, why, in the face of an extensive history of both drought and famine (Pankhurst 1985; Webb et al 1992), has agriculture in the highlands been able to maintain significant genetic diversity of traditional varieties of crop species? Table 1 presents historical data on drought and famine on the Horn of Africa and Ethiopia. Beginning from 253 BC in Ethiopia droughts and famines appear to have been fairly frequent. Yet the presence of genetically diverse crop species continues to the present day. What is the relationship between these processes of genetic erosion and the cultural ecology which prevails in the highlands?

Erosive process - conservation result?

Risk Aversion and the scramble to replant

Risk aversion acts as an important characteristic among farmers in the highlands, and processes recognized as important to genetic erosion play a large role in such risk aversion due to their contribution to food insecurity. The frequency and severity of agricultural problems which make up these processes have contributed over time to a position of extreme vulnerability. This, together with small field size and high populations, provides a context in which agricultural production is pursued with a strategy based largely on risk averse behavior focused on minimizing the ever present threat of increasing food insecurity.

This strategy primarily entails the rapid and intensive replanting of fields and parts of fields, as crops succumb to the various problems of doing agriculture in the highlands. This replanting takes place however with crop species different than those initially planted, with substitute crops selected to both be resistant to the problem at hand (drought, disease, pests, etc.) and able to produce a yield in the remaining growing season. Often a series of replanting takes place in a given set of agricultural seasons. And while individual fields are small, crop failure and the need to replant can be variable within individual fields. If a particular crop only partially fails within a field, then only part of the field will be replanted with a different crop. Such that subsequent to one or more replantings, a particular small field can comprise a patchwork of different crop species and varieties in different stages of maturity. And while the initial crop can be a non-traditional high yielding hybrid variety planted in the hopes that a good agricultural year will allow such crops to produce significantly, replantings usually take place with local varieties known to be drought or disease resistant. Local varieties, while not high yielding, nonetheless have the genetic ability to survive given the prevailing problem.

Thus the frequency and severity of agricultural problems, combined with the vulnerability of highland populations to significant food insecurity, creates a scramble to always attempt to produce something, regardless of the agricultural problem that presents itself in any season, due to the need to feed large populations off of small fields. However such a replanting institution would achieve very little if the genetically diverse seed varieties were not available and held always at the ready over large areas of the agricultural geography in the highlands. To a significant degree it is this desperate scramble to replant, caused by food insecurity, so as to always get some production from very small fields, operating over long periods of time, that is, in effect, the motor for the maintenance of a wide array of genetically diverse crop species in the highlands.

Food insecurity in areas of the world which contain crop genetic diversity can often lead to attempts by development agendas at replacing lower yielding traditional varieties with higher yielding hybrid varieties--thus comprising a genetically erosive process. While the Ethiopian extension service seeks to spread the use of hybrid, high yielding varieties of crop species among a wide array of farmers, in the highlands such crop replacement is problematic. Field sizes are generally too small for the extension package which is designed for a minimum sized field in terms of plowing (usually with oxen) seeds, fertilizer, herbicides and pesticides. As well, the extension service seeks to be sustainable, and thus the arrangement is to have farmers go into debt in order to obtain the extension package. But the package is not designed to effectively operate in times of climatic stress or other problems, and so the frequency of crop failure with hybrid crop varieties in the extension program is significant in the highlands. With both a failed crop and indebtedness, farmers who are already food insecure can be forced to sell productive assets in order to meet the requirements of their debt. As a result such farmers are often unable to continue in agriculture. It doesn't take many such cases in a community or larger area to convince other farmers that the extension package is too big of a risk, and is to be avoided. Other characteristics of the program can contribute to this point of view among farmers. For example the fact that the hybrid seeds included in the extension package do not produce seeds that themselves can germinate, can be a surprise that can

result in considerable food insecurity and ill will toward the extension program. It is also known among farmers in certain areas of the highlands that even in good agricultural seasons, seeds that come with the extension package at times do not germinate, due presumably to the lack of field trials specific to conditions in particular areas.

Food Insecurity Promotes Landrace Conservation?

Because much of the literature dealing with genetic erosion has to do with the processes that result in food insecurity (Hutchinson and Weiss 1999 and the references cited therein) it is worthwhile to examine how the occurrence of genetic erosion coupled with food insecurity takes place at the landscape scale. While ultimate and extreme food insecurity does result in the separation of people from agricultural pursuits (e.g., out migration, destitution, etc.) it is important to consider the progressive nature of this food insecurity and how this intersects with a spatial and demographic domain. Figure 3 illustrates how progressive food insecurity results in a sequence of coping options by those affected as food insecurity worsens. With increasing food insecurity (progression down the curve in Figure 3) more assets are sold off, and decisions made that are designed to stop the slide into further food insecurity. For those that do arrive at the bottom of the curve however, complete loss of assets and out migration does serve to ultimately separate them from agricultural pursuits and thus comprises genetic erosion. But for a given extreme food insecurity set of circumstances and point in time, what is the relative number of people that occupy the bottom of the curve, versus the proportion that are arrayed at various other points along the curve? How is such a situation represented spatially? And how does such an arrangement intersect with processes of genetic erosion or conservation?

Figure 4 places the curve from Figure 3 (dashed line) over a set of concentric isobars that illustrate in both a spatial and demographic sense, how people are arrayed along the curve in Figure 3 during many situations of food insecurity. Figure 4 illustrates that where extreme food insecurity or famine operates in a form catastrophic enough to compel out migration, sale of all assets, and hence separation from agricultural production (innermost isobar), there are also large numbers of people—and proportionally more than exist within the innermost isobar--that are not affected as severely (yet). Such a population does not reside within the innermost isobar and at the bottom of the curve in Figure 3, but rather are arrayed at various stages along the curve, all the way to being unaffected by food insecurity (top of the curve in Figure 3, and outermost isobar in Figure 4). Hence the extreme food insecurity that separates households and communities from agriculture, and hence causes genetic erosion, exists to a significant degree in pockets. Such pockets of extreme food insecurity is very frequently how famine begins and operates; with some local populations better off than others, as the socio-economic segmenting effects of extreme food insecurity plays out across an affected landscape. Figure 5 illustrates this pocket spatial nature of the existence of food insecurity in actual data for the Darfur region of neighboring Sudan. While occurring in a different human and biophysical environment than highland Ethiopia, the figure does generally represent the spatial aspect of food insecurity--with the most extreme forms of food insecurity existing in pocket locations, and most of the area and the wider population existing outside these pockets. While large scale

catastrophic food insecurity, such as the 1984/5 Ethiopian famine, does involve large populations across landscapes, such events begin in pockets, and less widespread and catastrophic events can play themselves out entirely in arrays of such pockets.

The implications of such a situation in a genetic erosion context is important. While the majority of people occupying most of the area around such pockets do not suffer extreme food insecurity, they are nonetheless very much aware of the existence of these pockets, and the severity of the problems underway within these. Given the history of food insecurity in Ethiopia (Table 1) this awareness is actually quite developed. Thus while a majority of people occupying such a landscape are arrayed at various points of food insecurity and vulnerability along the curve in Figure 3 their fear of course is that they too run the risk of eventually occupying such a pocket of extreme food insecurity. This, coupled with significant vulnerability, and the presence of very small fields from which to feed a large population, is again, the motor which drives such an aggressive replanting strategy in order to get something in the way of agricultural production in any given year. In other words aggressive replanting with local crop varieties in such an environment operates off of the food insecurity, poverty, vulnerability, and desperation of farmers not yet at the bottom of the curve in Figure 3 (innermost isobar of Figure 4), but who fear they could end up there.

Edge effect and Weedy Cousins

For the agricultural environment described here additional processes come into play that further encourage the maintenance of traditional varieties of genetically diverse crop species. Figure 2 not only illustrates the small plot sizes that comprise highland farms, but also a very significant edge effect created by so many small fields. As well, replanting parts of fields with different crops during the course of the agricultural season adds significantly to the overall edge effect between crops. The role of this edge effect in the maintenance of genetic diversity in traditional crop varieties is twofold. First, small patches of crops and many edges result in a greater proximity-mix of crops. For like varieties this allows for the enhanced probability of mixing of genes, and hence the potential for new varieties to emerge. This is an important process for the adaptation of plant varieties to new problems of climate (including climate change), disease, and pests.

The edge effect also allows proximity and interaction with the weedy cousins of crop varieties that frequently occupy field edge locations. These wild varieties contain a great deal of genetic diversity necessary for survival, but also do not produce as much in the way of food. Nevertheless their proximity to cultivated cousins allows for genetic traits to pass back and forth from weedy to cropped varieties, further facilitating a rich diversity of genetic possibility in the adaptation of new varieties and the maintenance of existing genetically diverse varieties. Such a situation results from the small plot sizes and replanting activities common in the highlands.

Seeds and Communities

While households in many areas of the Ethiopian highlands are compelled to keep a significant variety of traditional crop species on hand in the pursuit of food security, the

community level movement of seed varieties also plays a large role in seed availability and use. Due to the number of varieties in use, and the emergence of new varieties, considerable community level movement of seeds is needed and goes on so as to provide for widespread replanting needs. Trade in traditional seed varieties within and between communities is considerable in highland Ethiopia and provides an important mechanism by which existing varieties are replenished or acquired at the household level, and how new varieties are dispersed through a community.

The Dilemma

The situation described here for highland Ethiopia presents a significant dilemma in terms of food security and conservation of important agricultural biodiversity. If it is the food insecurity, poverty, vulnerability and hence desperation which compels small scale agriculturalists to scramble to continuously replant in the face of agricultural adversity, and in turn compels them to invest considerable effort in having a wide array of traditional seed varieties always on hand, then any improvement in food security and livelihoods would then result in a decreased need to aggressively replant, resulting in real genetic erosion. In other words improved food security would likely significantly reduce the drive to always get some production from very small plots, and hence decrease the need to always have a wide array of seeds on hand for this purpose. This in turn would reduce the availability of valuable landrace varieties containing significant genetic diversity. Certainly improved food security for highland Ethiopians should be a priority in relief and development agendas for the region. It remains to be seen however if this can be done while at the same time continuing the *in situ* conservation of important landrace agrobiodiversity.

While the landrace conservation situation in highland Ethiopia presents a dilemma with no easy answers, the issue is nonetheless very relevant to an array of emerging international negotiations and treaties regarding biodiversity. Agricultural biodiversity is a common topic in this domain. However this presently exists only with regard to the physical genetic material itself (seed stock). The difference of course is that unlike naturally occurring biodiversity, agrobiodiversity exists as a result of human interaction with plant species and the landscape via agricultural systems often over very long periods of time--as is the case with highland Ethiopia. That maintenance (and continued development) of agrobiodiversity continues to exist as a result of specific agricultural communities interacting with the landscape, means that a 'service' is being provided to the wider human community in terms of continued viability of important crop species. Such 'services' do not presently reside in the domain of international negotiation and treaty along with other issues pertaining to biodiversity.

In a changing world, much about emerging international issues have yet to be adequately dealt with. And in many cases appropriate approaches to navigating such issues in the international domain have yet to be found. The 'service' provided by highland Ethiopian agriculturalists which allows for the maintenance of important agrobiodiversity is such an emerging issue that has yet to be adequately considered with in the international arena.

References

- Chitrakon, S., Y. I. Sato, H. Morishima, and Y. Simamoto, 1999. *Genetic erosion of rice in Thailand*. Internet at:
<http://probe.nalusda.gov:8000/otherdocs/rgn9/v9p73.html>.
- Egziabher, Tewolde Berhan Gebre, 1991. Management of mountain environments and genetic erosion in tropical mountain systems: the Ethiopian example, *Mountain Research and Development*, 11(3): 225-230.
- FAO (2000) The role of biological diversity in feeding the world.
www.fao.org/biodiversity/foodsecur.
- Fowler, Cary and Pat Mooney, 1990. *Shattering Food, Politics, and the Loss of Genetic Diversity*. Tucson, The University of Arizona Press
- Hutchinson C and Weiss E (1999) Presented at the Technical Meeting on the FAO World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture (WIEWS). Prague, 21-23 June.
- Madeley, John, 1996. *Yours for food: plant genetic resources and food security*. Internet at Internet: <http://www.oneworld.org/aprodev/yours1.htm>
- Natural Resource Perspectives, Number 7, March 1996. Internet at:
http://www.oneworld.org/odi/odi_erosion.htm
- Office of Arid Lands Studies (OALS) (1991) Famine Mitigation.
Proceedings of Workshops Held in Tucson, Arizona, and Berkeley Springs, West Virginia. University of Arizona.
- Pankhurst R (1985) The history of famine and epidemics in Ethiopia prior to the twentieth century. Addis Ababa, Relief and Rehabilitation Commission
- Tripp, R., and W. van der Heide, 1996. *The erosion of crop genetic diversity: challenges, strategies, and uncertainties*. Overseas Development Institute
- Tuxill J (1999) As plant species disappear, the world becomes poorer. International Herald Tribune, Friday, Sept 24.
- UN Development Programme, emergencies Unit for Ethiopia (UNDP-EUE) (2000) Recent developments and events in Ethiopia. UNDP-EUE, Addis Ababa, 9 May.
- Webb P, von Braun J, and Yohannes Y (1992) Famine in Ethiopia: policy implications of coping failure at national and household levels. research Report No. 92, International Food Policy Research Institute. Washington DC

Zimmer, Karl S., 1992. The loss and maintenance of native crops in mountain agriculture, *GeoJournal* 27(1): 61-72.