FOOD FIRST
INSTITUTE FOR FOOD AND DEVELOPMENT POLICY
398 60th Street, Oakland, CA 94618 USA
Tel: (510) 654-4400 Fax: (510) 654-4551 E-mail: foodfirst@igc.apc.org www.foodfirst.org

POLICY BRIEF No 2

The Potential of Agroecology to Combat Hunger in the Developing World

by Miguel Altieri, Peter Rosset and Lori Ann Thrupp

October 1998

Miguel Altieri, Ph.D.
Department of Environmental Science, Policy and Management
University of California at Berkeley

Peter Rosset, Ph.D.
Institute for Food and Development Policy/Food First
Oakland, CA

Lori Ann Thrupp, Ph.D.
World Resources Institute
Washington, DC

To order additional copies:
Call 1-800-274-7826
or write or fax the Subterranean Company (distributor)
Box 160, 265 S. 5th Street
Monroe, OR 97456
Fax: (503) 847-6018
Price: $4.00 plus $1.50 shipping & handling

Introduction

In this policy brief we argue that the agroecological approach to food production offers more hope of combating hunger in a sustainable fashion than does the more conventional "green revolution" strategy. While agroecological technology is suitable for small farmers, has positive impacts on equity and is environmentally friendly, the green revolution and similar approaches have caused serious land degradation and have accentuated rural inequality—the root cause of hunger.

Hunger and the Green Revolution Approach

Hunger and malnutrition affect nearly 800 million people in the developing world. By and large those problems are not due to an absolute scarcity of food, but to the more complex issues of who grows food and how and where it is grown, how it is distributed, and finally, who has access to it. In this complicated web of causality, inequality is the outstanding driving force behind hunger. Misuse and over-exploitation of natural resources are other factors underlying food gaps. Any technological policy for rural and agricultural development must be judged on, among other factors, whether it tends to increase or decrease inequity in the distribution of and access to resources and food, and whether it ensures sustainability of resource use.[1]

Proponents of a 'second' green revolution (GRII) generally argue that scarcity and low agricultural productivity cause food insecurity and will also aggravate global hunger in the future. Those holding this perspective usually believe that "overpopulation" and food scarcity cause hunger, and likewise, dwell on aggregate global food production/consumption figures to justify GRII, but seldom look at distribution and disparities at the local or regional level. Therefore they propose a new wave of agricultural intensification based on increased fertilizer and pesticide use in Africa and parts of Latin America, bioengineered crop varieties, and trade policies that would allow northern food supplies to cover for any 'food gaps' remaining in the South after GRII.[2] Likewise, they usually promote the agroindustrial model that stresses uniformity, standardized technologies for large scale high-input and mechanized systems, aimed at maximizing yields of commercial crops, to fuel a global food system.

THE GREEN REVOLUTION[3]

The term 'green revolution' refers specifically to a strategy launched in the 1960s to alleviate hunger by boosting crops yields in third world countries. Strictly speaking, the strategy was based on breeding new varieties of key grain crops (wheat, rice and corn), which had a greater yield response to fertilizer and controlled irrigation than did the traditional varieties planted by most farmers. These varieties were thus called 'high response varieties,' or HRVs. In practice the HRVs were usually accompanied by 'technological packages' that included externally applied chemical fertilizers, pesticides (herbicide, insecticide and/or fungicide), and irrigation systems. While the broad application of this strategy during the 1960s, 70s and 80s coincided with significant increases in per capita grain production, critics point out that all too often it was not accompanied by a reduction in hunger. Reasons for this paradox include the failure of this strategy to address distributional issues of access to food and land, an inherent bias favoring larger farmers because of the costs of purchased inputs, and the tendency of large farmers to later mechanize, reducing rural employment. Critics also highlight ecological problems generated in these production systems, which threaten long-term productivity, including soil degradation, pest resistance to pesticides, and growing weed problems.

Yet, evidence from the first green revolution suggests that the GRII approach is unlikely to be the appropriate strategy to end hunger. Serious concerns have been raised by economic analysts, NGOs (non-governmental organizations), and farmers in many parts of the world. The original green revolution technological packages have in many cases generated soil, pest, and weed problems, sometimes leading to long-term yield decline.[4] At the same time inequality has usually grown, as larger farmers have benefited earlier and disproportionately from adoption of costly inputs.[5] The GRII emphasis on capital-intensive, off-farm, chemical inputs, is likely to both reinforce yield leveling or decline, and generate further inequity, thus making it a less than ideal policy package for attacking hunger. Furthermore, the dumping of Northern country food surpluses is already a key factor depressing productivity in the South, casting doubt on the soundness of further trade liberalization in basic foodstuffs. Finally, bioengineering usually produces varieties that are not locally adapted and whose purchase is difficult for cash-strapped farmers. The widespread introduction of such varieties poses environmental risks and can reduce the genetic diversity of food crops and varieties, elevating risk and food insecurity for farmers in many areas.[6]

Agroecology: A Better Approach

In contrast, the agroecological approach favored by increasing numbers of farmers, NGOs, and analysts around the world, offers several advantages.[7] First, it is a alternate path to agricultural productivity or intensification that relies on local farming knowledge and techniques adjusted to different local conditions, management of diverse on-farm resources and inputs, and incorporation of contemporary scientific understanding of biological principles and resources in farming systems. Second, it offers the only practical way to actually restore agricultural lands that have been degraded by conventional agronomic practices. Third, it offers an environmentally sound and affordable way for smallholders to sustainable intensify production in marginal areas. Finally, it has the potential to reverse the anti-peasant biases inherent in strategies that emphasize purchased inputs and machinery, valuing instead the assets that small farmers already possess, including local knowledge and the low opportunity costs for labor that prevail in the regions where they live. Thus it is an approach that is likely to decrease, rather than exacerbate, inequality, and also enhance sustainability.

THE MEANING AND PRINCIPLES OF AGROECOLOGY[8]

Agroecology is a scientific discipline that defines, classifies, and studies agricultural systems from an ecological and socioeconomic perspective. It is considered the scientific foundation of sustainable agriculture as it provides ecological concepts and principles for the analysis, design, and management of productive, resource-conserving agricultural systems. Agroecology integrates indigenous knowledge with modern technical knowledge to arrive at environmentally and socially sensitive approaches to agriculture, encompassing not only production goals, but also social equity and ecological sustainability of the system. In contrast to the conventional agronomic approach that focuses on the spread of packaged, uniform technologies, agroecology emphasizes vital principles such as biodiversity, recycling of nutrients, synergy and interaction among crops, animals, soil, etc., and regeneration and conservation of resources. The particular methods or technologies promoted by agroecologists build upon local skills and are adapted to local agroecological and socioeconomic conditions. The implementation of such agroecological principles within the context of a pro-poor, farmer-centered rural development strategy can generate healthy, equitable, sustainable, and productive systems.

Today there are thousands of examples where rural producers in partnership with NGOs and other organizations, have promoted and implemented alternative, agroecological development projects which incorporate elements of both traditional knowledge and modern agricultural science, featuring resource-conserving yet highly productive systems such as polycultures, agroforestry, the integration of crops and livestock, etc.[9]

There is enough evidence available—despite the fact that researchers have paid scant attention to these systems—to suggest that these agroecological technologies promise to contribute to food security at many levels. Just how productive and sustainable they are is to some degree still an empirical question. But it is likely that the prevalence of similar systems among smallholders is a factor in the universally observed inverse relationship between farm size and production, whereby smaller farms make far more productive use of the land resources than do large farms. Yet, even medium and large scale producers are increasingly making use of the agroecological approach, recognizing the advantages of these principles and techniques over conventional approaches.[10]

Critics of such alternative production systems point to lower crop yields than in high-input conventional systems[11]. Yet all too often it is precisely the emphasis on yield—a measure of the performance of a single crop—that blinds analysts to broader measures of sustainability and to the greater per unit area productivity obtained in complex, integrated agroecological systems that feature many crop varieties together with animals and trees. There are also cases where even yields of single crops are higher in agroecological systems that have undergone the full conversion process.[12]

Assessments of various initiatives in Africa, Asia, and Latin America show that agroecological technologies can bring significant environmental and economic benefits to farmers and communities.[13] If such experiences were to be scaled up, multiplied, extrapolated, and supported in alternative policy scenarios, the gains in food security and environmental conservation would be substantial. In this article we summarize some cases from Latin America and Africa to explore the potential of the agroecological approach.

Stabilizing the Hillsides of Central America

Perhaps the major agricultural challenge in Latin America is to design cropping systems for hillside areas that are both productive and reduce erosion. Several organizations have taken on this challenge with initiatives that emphasize the stewardship of soil resources, and utilization of local resources and inputs produced on-farm.

Since the mid 1980s, the private voluntary organization World Neighbors has sponsored an agricultural development and training program in Honduras to control erosion and restore the fertility of degraded soils. Soil conservation practices were introduced—such as drainage and contour ditches, grass barriers, and rock walls—and organic fertilization methods were emphasized, such as chicken manure and intercropping with legumes. Program yields tripled or quadrupled from 400 kilograms per hectare to 1,200-1,600 kilograms, depending on the farmer. This tripling in per-hectare grain production has ensured that the 1,200 families participating in the program have ample grain supplies for the ensuing year. Subsequently *COSECHA*, a local NGO promoting farmer-to-farmer methodologies on soil conservation and agroecology, helped some 300 farmers experiment with terracing, cover crops, and other new techniques. Half of them have already tripled their corn and bean yields; 35 have gone beyond staple production and are growing carrots, lettuce, and other vegetables to sell in local markets.[14]

Throughout Central America, *CIDDICO,* among other NGOs, has promoted the use of grain legumes to be used as green manure, an inexpensive source of organic fertilizer to build up organic matter. Hundreds of farmers in the northern coast of Honduras are using velvet bean *(Mucuna pruriens)* with excellent results, including corn yields of about 3,000kg/ha (more than double than national average), erosion control, weed suppression and reduced land preparation costs. The velvet beans produce nearly 30 t/ha of biomass per year, or about 90-100 kg of N/ha per year.[15] Taking advantage of well established farmer to farmer networks such as the *campesino a campesino* movement in Nicaragua and elsewhere, the spread of this simple technology has occurred rapidly. In just one year more than 1,000 peasants recovered degraded land in the Nicaraguan San Juan watershed. Economic analyses of these projects indicate that farmers adopting cover cropping have lowered their use of chemical fertilizers from 1,900 kg/ha to 400 kg/ha, while increasing yields from 700 kg to 2,000 kg/ha, with production costs about 22 percent lower than farmers using chemical fertilizers and monocultures.[16]

Scientists and NGOs promoting slash/mulch systems based on the traditional "tapado" system, used on the Central American hillsides, have also reported increased maize yields (about 3,000 kg/ha) and considerable reduction in labor inputs as cover crops smother aggressive weeds, thus minimizing the need for weeding. Another advantage is that drought resistant mulch legumes such as *Dolichos lablab* provide good forage for livestock.[17]

These kinds of agroecological approaches are currently being used on a relatively small percentage of land, but as their benefits are being recognized by farmers, they are spreading quickly. Such methods have strong potential and offer important advantages for other areas of Central America and beyond.

Agroecology in the Andean Region

In Peru, NGOs have studied pre-Columbian technologies in search of solutions to contemporary problems of high altitude farming. A fascinating example is the revival of an ingenious system of raised fields that evolved on the high plains of the Peruvian Andes about 3,000 years ago. According to archaeological evidence, these *waru-warus,* platforms of soil surrounded by ditches filled with water, were able to produce bumper crops despite floods, droughts and the killing frosts common at altitudes of nearly 4,000 meters.[18]

In 1984, several NGOs and state agencies created the *Projecto Interinstitucional de Rehabilitación de Waru-warus* (PIWA) to assist local farmers in reconstructing the ancient systems. The combination of raised beds and canals has proven to have important temperature moderation effects, extending the growing season and leading to higher productivity on the waru-warus, compared to chemically fertilized normal pampa soils. In the district of Huatta, reconstructed raised fields produced impressive harvests, exhibiting a sustained potato yields of 8-14 t/ha/yr. These figures contrast favorably with the average Puno potato yields of 1-4 t/ha/yr. In Camjata, potato yields reached 13 t/ha/yr and quinoa yields reached 2t/ha/yr in waru-warus.[19]

Elsewhere in Peru, several NGOs in partnership with local government agencies have engaged in programs to restore abandoned ancient terraces. In 1983 in Cajamarca, EDAC-CIED together with peasant communities initiated an all-encompassing soil conservation project. For over 10 years they planted more than 550,000 trees and reconstructed about 850 ha of terraces and 173 has of drainage and infiltration canals. The end result is about 1,124 ha of land under conservation measures (roughly 32 percent of the total arable land), benefiting 1,247 families (about 52 percent of the total in the area). Crop yields improved significantly. For example, potato yields went from 5 t/ha to 8 t/ha and Oca yields jumped from 3 to 8 t/ha. Enhanced crop production, fattening of cattle and raising of alpaca for wool, have increased the income of families from an average of US $108 per year in 1983 to more than $500 today.[20]

In the Colca Valley of southern Peru, PRAVTIR *(Programa de Acondicionamiento Territorial y Vivienda Rural)* sponsors terrace reconstruction by offering peasant communities low-interest loans or seeds and other inputs to restore large areas (up to 30 ha) of abandoned terraces. The terraces minimize risk in times of frost and/or drought, reduce soil loss, broaden cropping options because of the microclimate and hydraulic advantages of terraces, and improve productivity. First year yields from new bench terraces revealed 43 to 65 percent increases of potatoes, maize and barley, compared to crops grown on sloping fields. The native legume *Lupinus mutabilis* is used as a rotational or associated crop on the terraces; it fixes nitrogen, which is available to companion crops, minimizing fertilizer needs and increasing production.[21]

On farm research with *Lupinus mutabilis* in Bolivia provides an interesting example, shown in Table 1. While yields are higher in chemically fertilized and mechanically prepared potato fields, energy costs are also higher and net economic benefits are not greater than in the agroecological system. Surveys indicate that farmers prefer the latter alternative, as it optimizes the use of scarce resources (labor and capital), and is accessible to poor producers. Similar methods are being scaled up and multiplied, showing great potential for sustainable improvements in food security throughout the region.

Table 1. Performance of traditional, modern and alternative potato-based production systems in Bolivia.

	Traditional low-input	Modern high-input	Agroecological system
Potato yields (t/ha)	9.2	17.6	11.4
Chemical fertilizer (N kg/ha + P_2O_5 Kg/ha)	0.0	80 + 120	0.0
Lupine biomass (t/ha)	0.0	0.0	1.53
Energy efficiency (output/input)	15.7	4.8	30.5
Net income per *Boliviano* (Bs) invested	6.21	9.4	9.9

Source: Rist, S. 1992. Ecología, economía y tecnologías campesinas. *RURALTER* 10: 205-227.

Integrated Production Systems

A number of NGOs promote the integrated use of a variety of management technologies and practices. The emphasis is on diversified farms in which each component of the farming system biologically reinforces the other components (for instance where wastes from one component become inputs to another). Since 1980, *CET*, a Chilean NGO, has engaged in a rural development program aimed at helping peasants reach year-round food self-sufficiency while rebuilding the productive capacity of their small landholdings. The approach has been to set up several 0.5 ha model farms, which consist of a spatial and temporal rotational sequence of forage and row crops, vegetables, forest and fruit trees, and animals. Components are chosen according to crop or animal nutritional contributions to subsequent rotational crops, their adaptation to local agroclimatic conditions, local peasant consumption patterns and, finally, market opportunities. Most vegetables are grown in heavily composted 5 m^2 raised beds located in the garden section, each of which can yield up to 83 kg of fresh vegetables per month, a considerable improvement to the 20-30 kg produced in spontaneous gardens tended around households. The rest of the 200-square meter area surrounding the house is used as an orchard, and for animals (cows, hens, rabbits, and beehives).

Vegetables, cereals, legumes, and forage plants are produced in a six-year rotational system within a small area adjacent to the garden. Relatively constant production is achieved (about six tons per year of useful biomass from 13 different crop species) by dividing the land into as many small fields of fairly equal productive capacity as there are years in the rotation. The rotation is designed to produce the maximum variety of basic crops in six plots, taking advantage of the soil-restoring properties and biological control features of the rotation.

Over the years, soil fertility in the original demonstration farm has improved, and no serious pest or disease problems have appeared. Fruit trees in the orchard and fencerows, as well as forage crops, are highly productive. Milk and egg production far exceed that on conventional farms. A nutritional analysis of the system based on its key components shows that for a typical family it produces a 250 percent surplus of protein, 80 and 550 percent surpluses of vitamin A and C, respectively, and a 330 percent surplus of calcium. A household economic analysis indicates that the balance between selling surpluses and buying preferred items provides a net income beyond consumption of US $790. If all of the farm output were sold at wholesale prices, the family could generate a monthly net income 1.5 times greater than the monthly legal minimum wage in Chile, while dedicating only a relatively few hours per week to the farm. The time freed up is used by farmers for other on-farm or off-farm income generating activities.[22]

In the late 1990s Cuba has seen a remarkable recovery from the food crisis brought on by the 1989 collapse of trade relations with the former socialist bloc. Prior to the 1989 crisis and the subsequent tightening and extending of the U.S. embargo, Cuba had depended on trade for much of its food and agricultural inputs. The loss of the trade led to an estimated 30% drop in food intake by the population by 1992. Yet by 1996-7 Cubans once again enjoyed a reasonable level of food intake, as domestic production of most major food crops returned to or surpassed historic levels, though only a fraction of the pre-1989 quantities of chemical fertilizer and pesticide was being imported. Cuban success in self-reliant food production was achieved through substituting locally produced bio-fertilizers and bio-pesticides for the old imported chemical products, while farmers began to intercrop on a wide scale and, increasingly, integrate crops and livestock. This experience lends support to our contention that agroecological alternatives can work on a broad scale.[23]

On the ground in Cuba, the *Asociación Cubana de Agricultura Orgánica* (ACAO), a non-governmental organization formed by scientists, farmers and extension personnel, has played a pioneering role in promoting alternative production modules. In 1995 ACAO helped establish three integrated farming systems (called 'agroecological lighthouses') in cooperatives *(CPAs)* in the province of Havana. After the first six months, all three CPAs had incorporated agroecological innovations (tree integration, planned crop rotation, polycultures, green manures, etc.) to varying degrees, which, with time, have led to enhancement of production and biodiversity, and improvement in soil quality, especially organic matter content. Several polycultures, such as cassava-beans-maize, cassava-tomato-maize, and sweet potato-maize were tested in the CPAs. Productivity evaluation of these polycultures indicates 2.82, 2.17 and 1.45 times greater productivity, respectively, than monocultures. The use of *Crotalaria juncea* and *Vigna unguiculata* as green manures have ensured a production of squash equivalent to that obtainable applying 175 kg/ha of urea. In addition, such legumes improved the physical and chemical characteristics of the soil and effectively broke the life cycles of insect pests such as the sweet potato weevil.[24]

At the Cuban *Instituto de Investigaciones de Pastos*, several agroecological modules with various proportions of the farm area devoted to agriculture and animal production were established. Monitoring of production and efficiencies of a 75 percent pasture and 25 percent crop module, reveals that total production increases over time, and that energy and labor inputs decrease as the biological structuring of the system begins to sponsor the productivity of the agroecosystem. Total biomass production increased from 4.4 to 5.1 t/ha after three years of integrated management. Energy inputs decreased, which resulted in enhanced energy efficiency, from 4.4 to 9.5 t/ha (Table 2). Human labor demands for management also decreased over time. Such models have been promoted extensively through field days and cross visits by farmers.[25]

Table 2. Productivity and efficiency of an integrated production system in Cuba (75% of the area devoted to pasture and 25% to crops).

Productive Parameters	1st Year	2nd Year	3rd Year
Area (ha)	1	1	1
Total Production (t/ha)	4.4	4.9	5.1
Energy Produced (Mcal/ha)	3797	3611	4885
Protein Produced (kg/ha)	168	115	151
Number of people fed by one hectare	4	3.5	4.8
Inputs (energy expenditures, Mcal)			
Human labor	569	392	359
Animal work	16.8	16.8	18.8
Tractor energy	277.3	162.2	138.6
Energy Efficiency (output/input)	4.4	8.8	9.5

Source: SANE, 1998. *Farmers, lighthouses and NGOs: learning from three years of field activities*, SANE-UNDP, Berkeley, CA.

African Experiences

In the African context, positive results from agroecological approaches have also been achieved. The Senegal Regenerative Agriculture Center is working to promote sustainable agriculture based on soil regeneration for small-scale farmers who have suffered from soil degradation. The cropping system is a millet-groundnut rotation, and legumes are intercropped with cereals. Compost is also being used to restore soil fertility. Cows, goats, and sheep are usually kept by each household, and their manure is collected for the compost mixture. This project is operating in 11 villages, with active farmer participation. Results show that farmers can obtain an increase in millet grain of more then 400 kilograms per hectare if they put on at least two tones of compost. Similar yield increases were achieved with chemical fertilizers, but the cost-benefit ratio was less favorable.[26]

In Tanzania, a Soil Erosion Control and Agroforestry project was begun in 1980 in the Lushoto district. It included planting of perennial grass along contours to alleviate soil erosion and promote soil regeneration, as well as use of contour strips of trees, shrubs, and creeping legumes.

The combination of these integrated methods reduced erosion by an average of 25 percent, and improved soil health. Trees species are also valuable for fodder. Total yields per hectare increased by 64 percent for areas with grass strips, and 87 percent for areas with contours. Gross marginal returns were 74 percent higher in the contour systems compared to conventional approaches. These practices are being adopted by hundreds of people in this district, and offer promising alternatives for many other similar farming areas.[27]

Current experiences in Ethiopia also show the importance of respecting and upholding agroecological principles. As in other African nations, there have been heavy pressures to promote GRII technologies, particularly through the widespread imposition of uniform wheat and maize varieties, and a technology package policy that requires farmers to buy fertilizers and other inputs. However, local people and government and NGO officials have opposed this model, recognizing the problems and risks it entails, and they have defended and upheld the use of diverse and valuable local varieties of teff, sorghum, millet, and other grains that provide food security for the people.[28] They also have worked on reviving and "rescuing" local seed varieties in community-based seedbanks, and promoting integration of diverse sustainable farming practices in food security efforts.[29]

These diverse examples offer evidence of positive results, and also indicate increased adoption and spread of the methods, as farmers realize their benefits for food security and sustained production for market. In many parts of the world there is great potential for even wider application of these agroecological approaches.

Conclusions

In addition to the examples summarized above, there are thousands of experiences throughout the world of sustainable agriculture implemented at the local level by farmer organizations, NGOs, and other actors. These experiences demonstrate the feasibility of intensifying production, regenerating and preserving soils, and maintaining biodiversity, based on agroecological technologies and locally available resources. In fact, data from documented cases show that when correctly managed, agroecological systems:

- exhibit more stable levels of total production per unit area over time,
- produce economically favorable rates of return in both energetic and monetary terms,
- provide a return to labor and other inputs sufficient to provide an acceptable livelihood to small farmers and their families,
- ensure soil protection and conservation and enhance agrobiodiversity.

The combination of stable and diverse production with relatively high levels of production, internally generated and recycled inputs and nutrients, favorable energy input/output ratios, and articulation of both subsistence and surplus for market production, is a clear indication of what the agroecological strategy of intensification can achieve. This approach also enables farmers to reduce dependency on external capital-intensive inputs, take advantage of local resources, and avoid the vulnerability associated with monocultural production systems. As such, it is a more equitable and sustainable strategy than the conventional GR approach. These experiences show direct improvements for household food security and livelihoods. The values of such an approach are also being recognized and shown by scientists/researchers in the science of agroecology and its applications. Even modern commercial agriculture enterprises who have become tired of the high costs and constraints of conventional chemical-oriented approach are now realizing that the 'state of the art' in achieving success farming requires significant changes, to better understand, respect, uphold, and enhance agroecological principles and biological limitations/capacities.[30] As we move toward the 21st century, agriculture should take on a new orientation or paradigm to achieve win-

win-solutions: this orientation should be ecologically and socially oriented, knowledge-based, and farmer-friendly.

A major question often asked is why hasn't this agroecological approach spread more rapidly in recent decades? A major explanation is that powerful economic/corporate and institutional interests have backed research and development (R&D) for the conventional GR agroindustrial approach, while R&D for agroecology and sustainable approaches has been largely ignored or even ostracized. Only in recent years has there been growing realization of the advantage of alternatives.

Since there is increasing evidence and awareness about the advantages of agroecological alternatives, how can this approach and associated technologies be multiplied and adopted more widely and consistently? Clearly, a technological or ecological approach is not enough. Major changes must be made in policies, institutions, and methods of R&D to ensure that these agroecological alternatives are adopted, made accessible equitably and broadly, and multiplied so that we can realize their full benefit in terms of food security.

The challenge is to increase the investment and research into this strategy, and to scale-up projects that have already proven successful, thereby generating a meaningful impact in the income, food security, and environmental integrity of the world's population, and especially the millions of poor farmers yet untouched by modern agricultural technology. Existing subsidies and policy incentives for conventional chemical approaches must be dismantled, and institutional structures and partnerships and educational processes must change to enable this agroecological approach to blossom.[31] In addition, participatory, farmer-friendly methods of technology development must be incorporated, ensuring that women, men, elders, and marginalized poor farmers or labor groups are included in development of alternatives. If we fail to seize this opportunity, the existing cases will remain as "islands of success" in a sea of deprivation, merely living testimonies of the potential of the "path not taken" to feed the rural poor. On the other hand, if we go forward to widely support and develop an agroecological approach, humanity can benefit from its potential to address the inequity, hunger, and environmental degradation that so often accompany high-input, energy intensive, corporate-style agriculture.

Footnotes

1 Lappé, F.M., J. Collins and P. Rosset, with L. Esparza. 1998. *World Hunger: 12 Myths, Second Edition.* Grove Press and Food First Books, New York.

2 Food and Agriculture Organization of the United Nations. 1996. "Lessons from the green revolution: towards a new green revolution" in *World Food Summit: Technical Background Documents,* vol. 2. FAO: Rome; Agriculture and Rural Development Department, World Bank, 1991, "Agricultural Biotechnology: The Next 'Green Revolution'?" *World Bank Technical Papers* no. 133.

3 For a summary, see Lappé et al., op cit., ch. 5.

4 Lappé et al., op cit., ch. 5. See also K. G. Cassman and R. R. Harwood, "The Nature of Agricultural Systems: Food Security and Environmental Balance," *Food Policy* 20, no. 5 (1995): 439–454, 447–448; K. K. M. Nambiar, "Long-Term Experiments on Major Cropping Systems in India" in *Agricultural Sustainability,* ed. Vic Barnett et al., 133–170; D. Byerlee, "Technical Change, Productivity and Sustainability in Irrigated Cropping Systems of South Asia: Emerging Issues in the Post-Grain Era," *Journal of International Development* 4, no. 5: 477–496.

5 Donald K. Freebairn, "Did the green revolution concentrate incomes? A quantitative study of research reports," *World Development* 23, no. 2 (1995): 265–279.

6 Altieri, M.A. 1997. "The environmental risks of transgenic crops." *Environmentally Sound Social Development Proceedings,* Conference on Biosafety and Biotechnology, World Bank, Washington, DC, Oct. 1997.

7 Altieri, M.A. 1996 op.cit.

8 Altieri, M.A. 1996. *Agroecology: the Science of Sustainable Agriculture.* Westview Press, Boulder; Gliessman, S.R. 1998. *Agroecology: Ecological Processes in Sustainable Agriculture.* Ann Arbor Press, Michigan.

9 Pretty, J.N. 1995. *Regenerating Agriculture: Policies and Practices for Sustainability and Self-Reliance.* Earthscan, London; Thrupp, L.A. 1996. *New Partnerships in Sustainable Agriculture.* World Resources Institute, Washington D.C.

10 UNDP 1995. *Benefits of Diversity.* UNDP, New York; Lampkin, N. 1992. *Organic Farming.* Farming Press, Ipswhich, England.

11 Borlaug, N. 1992. "Small-scale agriculture in Africa: the myths and the realities: feeding the future," *Newsletter of the Sasakawa Africa Association,* 4:2.

12 Altieri, M.A. and P. Rosset 1995. "Agroecology and the conversion of large-scale conventional systems to sustainable management." *International Journal of Environmental Studies* 6: 1-21.

13 SANE 1998. *Farmers, NGOs and Lighthouses: learning from three years of training, networking and field activities.* SANE-UNDP, Berkeley.

14 Reijntjes, C. et. al. 1992. *Farming for the Future: An Introduction to Low-External-Input and Sustainable Agriculture.* MacMillan, London.

15 Thurston, H.D. et. al. 1994. *Slash/Mulch: How Farmers Use It and What Researchers Know About It.* CIIFAD-CATIE, Ithaca, NY.

[16] Holt-Gimenez, E. and Ruben Pasos. Undated. "'Campesino a Campesino'": el potencial campesino de generación y transferencia del Rio San Juan, Nicaragua." *Cuadernos del CIPRES,* Managua, Nicaragua; Holt-Gimenez. E. 1996. "The campesino a campesino movement: farmer-led, sustainable agriculture in Central America and Mexico." *Food First Development Report* No. 10. Oakland: Institute for Food and Development Policy

[17] Thurston et. al. op.cit.

[18] Erickson, C.L. and K.L. Chandler 1989. "Raised fields and sustainable agriculture in the lake Titicaca basin of Peru." In: *Fragile lands of Latin America.* J.O. Browder (ed). Westview Press, Boulder.

[19] Altieri, M.A. 1996. *Un enfoque agroecologico para el desarrollo de sistemas de producción sostenibles en los Andes.* CIED, Lima.

[20] Sanchez, J. 1994. "A seed for rural development: the experience of EDAC-CIED in the Mashcon watershed of Peru." *Journal of Learnings* 1: 13-21.

[21] Treacey, J.M. 1984. "Agricultural terraces in Peru's Colca Valley: promises and problems of an ancient technology." In: *Fragile lands of Latin America.* J.O. Browder (ed). Westview Press, Boulder.

[22] Altieri 1996, op.cit.

[23] Rosset, P.M., 1997. "Alternative agriculture and crisis in Cuba," *Technology and Society* 16(2)19-25; P.M. Rosset, "Alternative agriculture works: the case of Cuba," *Monthly Review* 50(3):137-146.

[24] SANE 1998, op cit.

[25] SANE 1998, op cit.

[26] From UNDP, 1992. op. cit. See also Thrupp, L.A. 1998. *Cultivating Diversity: Agricultural Diversity and Food Security.* Washington D.C.: WRI.

[27] UNDP, 1992 op. cit.

[28] See for example Mario Pareja. 1997. "Letter to the editor." *Food First News & Views* 19(65):2.

[29] From field visits in Ethiopia, 1997. Interviews with Dr. Tewolde Behran, Ethiopia EPA, Addis Ababa.

[30] Based on interviews with sustainable enterprises in Northern California, particularly in the grape and vinegrape industry.

[31] Thrupp, L.A. 1996. op.cit.