DISCUSSION PAPER

BUILDING RESILIENT FOOD SYSTEMS

THROUGH AGROECOLOGICAL PRINCIPLES AND PRACTICES

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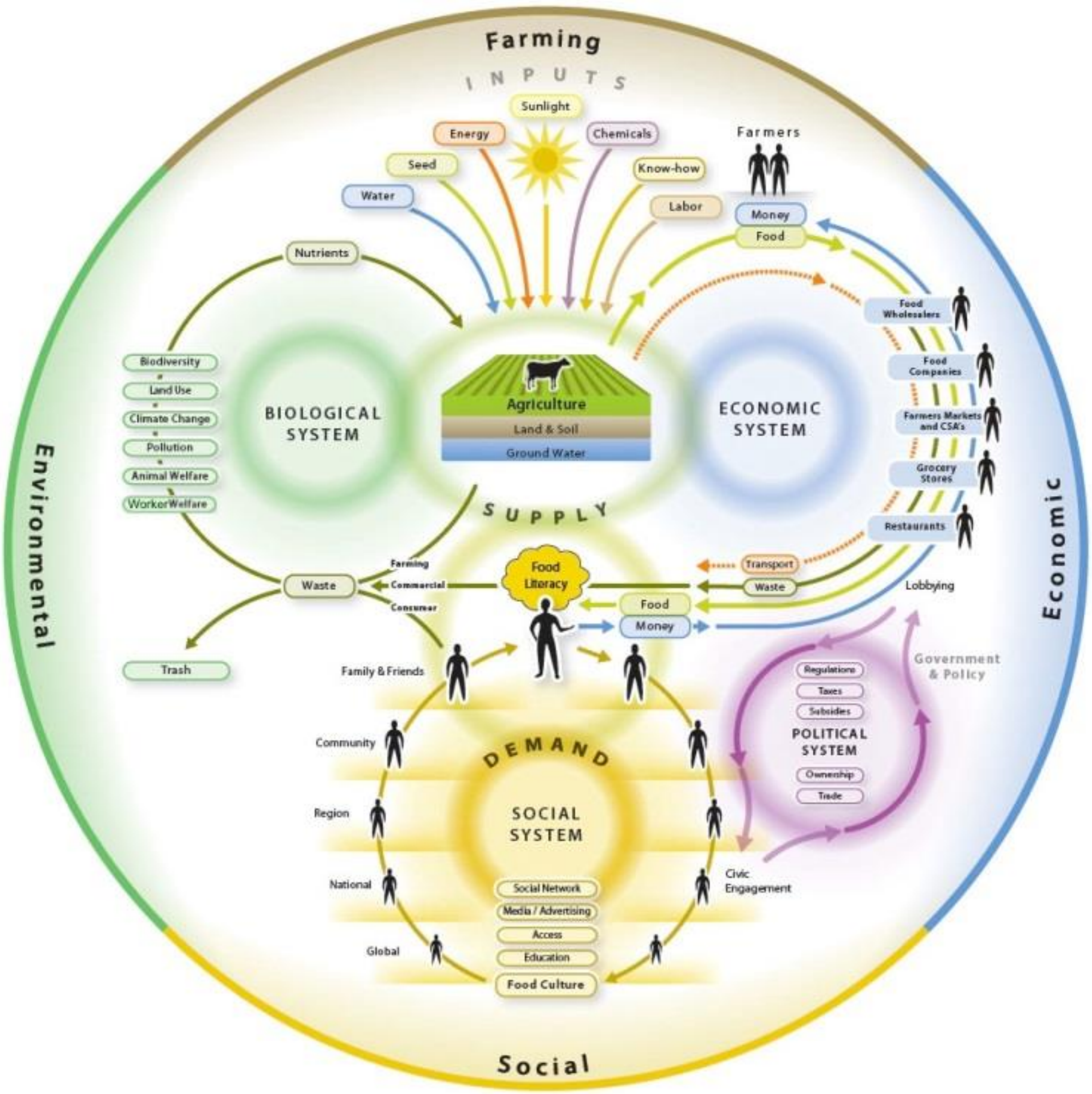
Introduction

Agricultural productivity and food security are inherently dependent on the human and ecological systems that sustain them. It is widely accepted that food systems around the globe are facing serious and persistent challenges that affect farmers and consumers both in developed and developing countries and that these challenges must be confronted to feed the ever-increasing population sustainably. The onset of industrialized agriculture in the late 1960s and the globalized nature of food production and trade have made it increasingly important to use a systems perspective to better understand agricultural production systems and markets as well as the impact that interventions in these systems have on both smallholder farmers and agroecosystems. At the same time that new technologies and open markets have enhanced commercial farm productivity and profitability, hard lessons have also been learned regarding the trade-offs that might occur when achieving these gains: Some countries have increased the value and volume of export crops only to experience a decrease in the food security of their more vulnerable populations; smallholder farmers who transition exclusively to cash crop production have gone hungry when the global prices of the new product crash because of market instability (e.g., coffee); technologies expected to feed the hungry instead feed animals with high value products that are inaccessible to the poor; methods and inputs meant to increase productivity have, at times, depleted and destroyed water resources and soil nutrients; and genetic technologies, while offering some potentially promising innovations, still provoke questions about their longer-term effects on human and ecosystem health (e.g., they may decrease diversity of seed stock, thus increasing dependency of farmers on a limited number of seed and input sources). As food systems have become increasingly industrialized and globalized, it has become more and more necessary to understand these distinct linkages within food system components, both locally and across multiple geopolitical spheres, and to identify the true drivers of sustainable food networks.

A **food system** refers to the components (i.e., markets, infrastructure, land, agricultural production systems, people and animals) and the set of activities and relationships that interact to determine what type, how much, by what method and for whom, food, feed or fiber is produced, processed, distributed and consumed (adapted from Pimbert, et al 2001). While a food systems perspective is necessary at the global level, it is equally important to apply this lens in working with smallholder farmers, whose agricultural production and sources of food for consumption may include both subsistence and cash cropping, and be determined not only by local market forces but also by global commodity markets. Taking a food systems perspective to Mercy Corps' work enables a comprehensive view of the different products, stages, inputs and outputs associated with agricultural production, from farm to markets to tables. Although attempts to understand the variety of complex interactions of our food system can seem overwhelming, it is important to embrace this complexity as it better prepares us to analyze and predict how interventions or disturbances in one component of the food system may affect other components, both within and outside of the defined system. Understanding interactions within the food systems that development programs engage with will help ensure that smallholders can both lift themselves out of poverty in the short term and better adapt to and absorb the inevitable shocks they might face in the future. Leveraging food systems analysis to improve resilience requires that we pay attention to the relationships between key system components and ask sometimes difficult questions. Questions must be asked concerning the potential impacts certain production methods and inputs might have on longer-term productivity of the agroecosystem and sustainability of natural resources.

Map of Food System Components and Relationships



Source: Nourish Food System Map; used with permission from http://www.nourishlife.org/teach/food-system-tools/

It is also necessary to address the potential of agricultural development programs to increase vulnerability to hazards such as market shocks, climate change and natural disasters when designed without due consideration of externalities. Building resilience in food systems requires supporting the capacities of farmers, households and other food system actors to be flexible and adapt to economic, ecological and social shocks and stresses at various scales. In this respect, it is useful to refer to existing documentation of trends in climate variability, frequency of extreme weather events and human-interfaced agroecosystem degradation that may turn into threats over time. Agroecology provides a useful lens for understanding important interactions between smallholder farmer's livelihood strategies, the ecological health of the agroecosystems they depend on and the broader food systems that can range from the local to the global.

Agroecology is defined in a variety of ways by researchers and practitioners. Dr. Stephen Gliessman, in the forthcoming 3rd edition of his textbook, "Agroecology; the ecology of sustainable food systems," (2015) defines agroecology as ''the science of applying ecological concepts and principles to the design and management of sustainable food systems" (Gliessman 2015). Rose Cohen and the Community Agroecology Network (CAN) elaborate on this definition, promoting agroecology as a "whole-systems approach to agriculture and food systems development based on traditional knowledge, alternative agriculture and local food systems experience." While the application of ecological principles and practices for sustainable production is a cornerstone of agroecology, many farmer-practitioners and thought leaders also emphasize the importance of agroecology as a social movement and, ultimately, a means of achieving food sovereignty and food justice for producers and their communities.

An agroecological approach recognizes the multifunctional dimensions of agriculture and facilitates progress toward a broad range of equitable and sustainable development objectives:

- *Increased Ecological Resilience* and reduced risk to changing environmental conditions
- *Improved Human Health and Nutrition* through more diverse, nutritious and fresh diets, and reduced incidence of pesticide poisoning among workers, communities and consumers
- *Conservation of Natural Resources* through enhancement of biodiversity, soil organic matter, water quality and quantity, and ecosystem services (e.g., pollination, climate regulation, erosion control)
- *Economic Stability* through more diverse sources of income, reduced vulnerability to single commodity price swings and spreading labor and production benefits over time
- *Climate Change Mitigation* through increased energy efficiency, reduced reliance on fossil fuel and fossil fuel-based agricultural inputs, and increased carbon sequestration and water capture in soil
- *Increased Social Resilience and Institutional Capacity* through increased ecological literacy, improved integration of local and scientific knowledge and strengthening of social support networks

(International Assessment of Agricultural Knowledge, Science and Technology for Development 2008)

If one goal of agricultural development is to build the resilience of agroecosystems and the communities that depend on them, projects implemented in resource-scare environments should be designed with an understanding of the underlying vulnerabilities faced by food production systems and consideration of the potential agroecological footprint of the program.

Shocks, Threats and Challenges to Resilience in Food Systems

Threats to various components of food systems, both realized and theoretical, can generally be classified as shocks or stresses. **Shocks** are events which are often unexpected, unpredictable, have a sudden onset and relatively high impact over a short time duration – e.g., hurricanes, tsunamis, price shocks and armed conflict. They are hard to prepare for and require long-term planning and investment that is more difficult to obtain, such as improved housing in hurricane or tsunami-prone localities. **Stresses** are often more predictable and can be visualized as cycles or trends, which occur slowly, but consistently, over longer periods of time – e.g., seasonal fluctuations in precipitation and temperature, land degradation, price instability, ineffective governance and population pressures. Stresses are easier to monitor and predict, allowing for the development of adaptation strategies oriented towards resilience. For example, soil erosion is a common phenomenon around the world which continues to stress agricultural production. With an increase in extreme weather events, we can expect that surface erosion will also intensify. We can respond to this trend by incorporating soil conservation practices into our agricultural programming, regardless of the objective (e.g., subsistence or market production). Various sources, including United Nations Development Programme's (UNDP) "Africa Human Development Report 2012: Towards a Secure Future" (UNDP 2012) have outlined a number of threats to various scales of food systems and their resilience.

***Climate change*:** Changes in climate and associated natural hazards represent some of the most serious threats to food systems. These can take the form of devastating and unpredictable disasters as well as longer-term trends or cycles of increasing temperatures, droughts or high rainfall, which frequently result in crop losses. Supporting rural households to become more resilient to climate change over the long term requires systemic interventions that target agroecosystems as well as household, social and market dynamics. On the one hand, agricultural and livestock activities are major contributors to anthropogenic greenhouse gas (GHG) emissions globally. Other food system contributors to GHG emissions are related to food processing, transportation, marketing, consumption and waste. On the other hand, these changes in temperature, precipitation and extreme weather events will affect the production capacity and resilience of these same agricultural systems. Temperature increases will result in crop failures and a higher incidence and severity of pests and diseases. Changes in and volatility of rainfall amounts will result in droughts or floods and, again, increase risks of pests and diseases. A higher frequency of extreme weather events, such as floods, hurricanes and droughts, can destroy agricultural infrastructure and farmland. Agriculture's role in contributing to climate change or mitigating its effects will largely depend on the design and management practices employed in the production system. This complex interaction between agriculture's contribution to greenhouse gases and climate change and the potential effects climate change and associated shocks have on agricultural production and food systems begs the question as to whether agricultural development programs should actively promote production strategies known to be dependent on methods or technologies that contribute to climate change, when other strategies may exist to meet similar production goals.

***Political and economic instability and conflict*:** This factor is perhaps the hardest to respond to, but one that has tremendous impact on food systems. When countries face violent conflict or economic crisis, many food system components can be disrupted, especially those dependent on imported inputs for production and food commodities for consumption. A decrease in the frequency and intensity of these types of conflicts would likely result in more resilient food systems. "From Conflict to Coping" (Kurtz and Scarborough 2012) highlighted the important link between peace building and resilience by showing that reducing local conflicts in pastoral areas of Ethiopia enabled pastoralists to utilize traditional adaptive coping strategies to access water and pasture, thus enhancing resilience in their food system. Creating change at this level requires multi-actor policy strategies that include donors, government institutions and both international and local organizations.

Increases in and volatility of food and energy prices: Market instability and volatility is a major threat to rural households, from the perspective of selling products for income as well as from the standpoint of buying food and other staples for household consumption. Price spikes in food commodities can create conditions of food insecurity for households that depend on purchasing food. On the other hand, price decreases of cash crops produced by a household can severely limit its purchasing power for food. Capturing or improving additional stages of a food value chain can represent an opportunity for households to attain more resilient food systems, but it also can pose risks if the context-specific factors, both local and global, are not considered. It is thus difficult to generalize how any one value chain intervention will impact the food system and food security for smallholder farmers. Since broader food systems are also linked to the global markets through their connection to agricultural commodities, crop price spikes can have considerable effects on the ability for households to access specific crops and products. Similarly, many components of any food system (e.g., production, transportation, processing, cooking/utilization, etc.) are dependent on energy. Increases in the price of energy (gas, oil, electricity) may result in price increases that strain both smallholders' abilities to produce and distribute their products as well as households' abilities to utilize food. Value chain facilitation that increases smallholders' dependence on volatile food and energy markets for inputs or production-based income may leave them overexposed to future shocks.

Poor farming practices and agroecosystem management: Certain production strategies and ecosystem management practices may increase vulnerability to climate shocks, pests and crop disease, thus negatively affecting the capacity of the agroecosystem to absorb, adapt to and recover from shocks. Management threats to agroecosystem resilience include the following:

- *Agroecosystem simplification:* Simplified agroecosystems are those that rely on only one or two crops and that fail, at least on some level, to mimic the more complex, naturally occurring ecosystems of a particular region. Monocultures (the cultivation of only one crop), for example, are more susceptible to pest and disease outbreaks, economic shocks due to price volatility and near complete crop loss due to the weather. Agroecosystems that possess structural and functional diversity may be better protected against losses from weather events. Systems where diversity is lost or intentionally destroyed may increase risk and decrease adaptability over the long term.

- *High dependency on external, synthetic fertilizers:* While synthetic fertilizers can present an efficient option to increasing crop yields, they do little to increase the long-term natural fertility of the soil and may cause dramatic imbalances within the soil and damage water resources and human health if used inappropriately. The costs and benefits to using synthetic fertilizers are often assumed, and not often calculated. Real-world expected yield increases are crop specific and may or may not differ significantly from more knowledge-based practices, especially over the long term. Prices of certain fertilizers are highly dependent on factors outside of farmer's control, and a sharp increase in prices or a reduction in access can severely damage the production capacity of a smallholder system that is overly dependent on synthetic fertilizers for temporarily increasing soil fertility. Other options for increasing fertility exist, especially through closed nutrient cycles that use plant biomass to provide at least a portion of the needed fertility.

- *High level of dependency on external, synthetic pesticide:* Synthetic pesticides (insecticides, fungicides, herbicides, etc.) can be efficient in controlling pests and disease, and prudent use may be necessary for certain crops. Overuse, however, can also damage natural pest-regulating mechanisms and soil microorganisms. Pesticides kill not only the offending pests but also the beneficial insects that feed on these crop pests, thus creating longer-term dependency on purchasing pesticides to control pests, rather than taking advantage of natural ecological processes. Hence, a reduction in access or an increase in price can severely damage the productive and adaptive capacities of a smallholder farm system that has become overly dependent on these inputs. Soil microorganisms and mycelium that are important to long-term soil health may also be negatively affected by pesticides/fungicides.

- *Intensive tillage* degrades soil structure, harms beneficial insects and soil microbes, and increases loss of topsoil through erosion, thus affecting the long-term health of the soil and nutrient availability for crop production.

- *Uninformed and unrestrained promotion of modernized practices and external technologies* may undermine existing local knowledge of ecosystems, weather, soil and local seed varieties, which may prove invaluable as part of the resilience toolkit. An integration of local knowledge and modern science and technology is bound to yield more holistic solutions to production challenges.

Challenges to smallholder household food security: Many farming households in developing countries cover their food needs through a combination of agricultural production for subsistence and purchase of food from other sources. While livelihood diversification represents an important strategy for rural families to maintain stable food systems, such diversification must not increase exposure and vulnerability to any one risk. A diversification that builds resilience ensures various agriculture or broader livelihood strategies are adapted to mitigate effects of any one shock to the household by spreading risk across various anticipated shocks. Design of the smallholder farm system presents a number of the following challenges to the food system and food security:

- *Limited sources of income that may hinder food access:* Income diversification provides a buffer to households in terms of funds to purchase necessary food. Those households that have only one or a few sources of income are more likely to go hungry if that income is disrupted. For example, when the green bean coffee price crashed in late 1990s, many households in Latin America that were dependent on coffee to generate income did not have enough cash to buy food and were not producing any of their own, thus impacting food security. Income diversification allows for maintenance of cash flows even if one or two sources are disrupted, provided that the diversification spreads risk across various anticipated shocks.

- *Limited production for consumption that may affect household food availability:* Households that use all of their land and resources for the production of cash crops to generate income are vulnerable to stresses or shocks that affect the production of these specific crops as well as to their prices and markets. If there is no diversity in food produced by the household to mitigate a harvest or market failure of a particular crop, that household will be overexposed to certain risks, leaving it more vulnerable to food insecurity and hunger. On the other hand, if households diversify and produce for consumption and markets, they better able to spread out the risk of losing their full capacity to acquire food.

- *Lack of adequate infrastructure for food access:* Adequate storage facilities, roads and markets are important examples of the infrastructure that ensures food systems function efficiently. A lack or sudden unavailability of these resources is a serious threat to food access and availability for households. In terms of resilience, infrastructure that supports the food system should not only be adequate for its intended purpose (e.g., food storage), but also be designed to withstand potential shocks (e.g., hurricanes, floods, armed conflict) or stresses (e.g., normal fluctuations in the rainy season).

- *Limited knowledge of health and nutrition:* Optimal nutrition and food utilization requires that household members have the capacity and knowledge to make the right decisions at the right time for individuals and families to attain food security. This component is already part of most food security programs, but within the context of improving resilience of households, it is important that households have the knowledge and information that can prepare them to adapt to changing climate and market patterns that may affect food and nutrition security.

Agroecology and Resilient Food Systems

Mercy Corps' agricultural and food security strategies focus on building capacities of individuals, households and communities to adapt to, respond to and recover from shocks and stresses that may affect their income and food consumption. These priorities are at the heart of the concept of **resilience**, which Mercy Corps' defines as: the capacity of communities in complex social-ecological systems to learn, cope, adapt and transform in the face of social, economic, and ecological shocks and stresses. Hence, a resilient food system not only functions adequately when food is produced and distributed under normal conditions, but it also is able to absorb, adapt to, and respond and/or recover from shocks and stresses.

Key Agroecological Principles to Support Food System Resilience

1. Preserve and enhance agroecosystem biodiversity
2. Enhance soil fertility and nutrient cycling
3. Conserve water
4. Support ecological pest- and disease-regulating mechanisms
5. Minimize use of external synthetic inputs to reduce cost, dependence and harm to agroecosystem
6. Manage beneficial ecological relationships
7. Maximize renewable energy potential
8. Diversify livelihoods to minimize risk exposure to shocks and stresses
9. Prioritize and enhance local food security, nutrition and health
10. Integrate local and scientific knowledge through appropriate practices and technology
11. Strengthen and empower local organizations
12. Facilitate Shared governance of natural resources

Adapted from: http://agroecology.org/Principles_List.html;
Sources: Principles of Agroecology and Sustainability n.d.; Gliessman 2006; Gunderson 2010

Resilience in food systems may be supported by agroecological approaches that minimize depletion and destruction of natural capital and are net energy and nutrient producers at the agroecosystem level. These systems will also aim for optimal productivity and yields, rather than maximum production or profit in disregard of externalities. This optimal productivity is achieved through production principles and practices that protect longer-term absorptive and adaptive capacities of the agroecosystem and regenerate farmer's natural assets rather than depleting them. Selected agroecological principles that are especially useful in facilitating these sustainable and productive linkages between households, agroecosystems and food systems are presented below.

***Preserving and enhancing crop biodiversity*:** Resilience in the face of climate change, natural disasters, food price volatility, devastating pests and viruses, and other shocks to food production and access demands a diversity of production within smallholder farm systems. *Crop diversity reduces the risk of farmers and their families suffering negative economic and nutritional consequences due to price volatility and weather hazards*. In addition to promoting crop diversity for consumption and sale, facilitating farmer-managed techniques that increase biodiversity can enhance resilience to new pest and disease vectors likely to arise as a result of climate change and can greatly improve pest management without the need to rely on expensive and often toxic external inputs. From an agroecological perspective, inherently diverse, natural ecosystems are the most adapted and most sustainable systems for the particular region where they developed (Gliessman 2006). Thus, designing for diversity emphasizes the mimicking of natural ecosystems in ways that enhance the multitude of endogenous biological interactions between different system elements. Mimicking natural ecosystems enables beneficial relationships in the system between microbial communities in the soil, insects, plants and animals, as well as preserving "wild" spaces and ensuring species and genetic diversity. Examples of mimicking natural ecosystems include intentionally designed agroforestry systems (combinations of crops with trees) in areas where natural ecosystems are forests, or planting perennial grain crops in areas that were once prairies. Enhancing biodiversity allows natural agroecological processes and the ecosystem as a whole to build soil nutrients and natural resistance to pests and diseases, services typically performed by external inputs in monocrops where these natural processes are removed. Through "companion planting," beneficial interactions between plants as well as the integration of livestock elements can be enhanced to improve soil fertility and provide desired products. The specifics of this diversification will depend on the needs of farmers and their families, the characteristics of local agroecosystems, and the ecology of a particular region.

Benefits of Agrobiodiversity for Coffee Household Livelihoods

In El Salvador and Nicaragua, smallholder coffee farmers manage several agricultural plots with high levels of plant agrobiodiversity. A study conducted over more than a decade demonstrated that these farmers cultivate important products (food, firewood, fruit and timber) as well as cash-generating crops (coffee and vegetables). Annual firewood contributions from agroforestry systems had a value of $167 and $71.50 in Nicaragua and El Salvador, respectively. This is important for households that report average monthly incomes of between $35 and $170. In addition, these households also reported obtaining an average of 40 percent of the annual corn and bean supply from these plots. An agricultural production strategy that combines both cash and consumption crops has helped these farmers resist green coffee bean price crashes and helped to conserve local agrobiodiversity. Projects executed by Catholic Relief Services (CRS), Heifer International and the Community Agroecology Network, among others, are working with coffee farmers to maintain or increase this agricultural diversification strategy to enhance the food security of these households. Some debate exists as to the need to focus on *livelihood diversification*, which would also include non-agricultural strategies to generate income. (Mendez 2010)

Diversified production is also being promoted as a strategy for leveraging agriculture for improved nutrition as such diversification has potential to provide improved income streams, reduce the cost of a nutritious diet, empower women and reduce seasonality in production and consumption of nutritious foods (Mottram 2011). Analyses of the various economic trade-offs and the positive and negative externalities of various diversification options are necessary to ensure that farmer livelihoods are sufficient and that diversification is not employed at the expense of household food security.

Maximizing energy potentials and nutrient cycling: An agroecological approach recognizes the need to utilize the *often-untapped energy and nutrient potential* inherent in the agroecosystem to produce the maximum benefit with minimum external inputs. This principle focuses on utilizing design methods and technologies to slow, spread and store water and nutrients within the agroecosystem as well as to optimize use of productive resources from the environment and from what are normally considered waste products. Through facilitating intelligent design of smallholder farm systems in our programs, it is possible to utilize different combinations of plants, animals, soils, water, sun, people and even gravity to achieve maximum synergistic effects. This synergism ultimately results in the slowing of entropic loss of nutrients and resources within food production systems and makes them available for increased productivity. Strategies and techniques for energy capture and nutrient cycling include the following:

- *Biomass Recycling* – no biomass goes to waste
- *Water Harvesting* for irrigation, soil quality and building/maintenance of water tables
- *Solar Technologies* for harvesting the sun's energy to manage energy needs
- *Gravity* potential for nutrient, water and waste flows
- *Microclimate Management* to minimize water loss due to solar radiation through increased soil cover, mulch farming, no-till agriculture and cover crops
- *Earthworks* (contour bunds, net 'n' pan techniques, swales) for minimizing soil erosion, sinking and storing water and topsoil nutrients, and maximizing water harvesting in arid agriculture/pasturelands
- *Animal Waste* cycling through use of livestock in intelligent systems design for fertilizer
- *Aquaponics Systems*
- *Companion Planting* for synergistic nutrient and microclimate needs and mulch production
- *Composting* of biomass and waste to build soil composition in depleted environments

Maximizing energy and nutrient capture and cycling in farm systems will also support another key agroecological principle, which focuses on *reducing reliance on off-farm inputs*. While certain inputs are useful, resilient food systems will better ensure that households and smallholders are less reliant on outside energy and inputs, and are thus more capable of adapting and maintaining productivity in the case that these external inputs become unaffordable or unavailable. Less reliance on off-farm inputs also better ensures the health of the agroecosystem and the farmers themselves as pesticide and other chemical use is minimized.

Crop Diversity for Reduced External Fertilizer Application

In an example of participatory biodiversity enhancement, researchers from Michigan State University have been working with Malawi maize farmers for over a decade to test different diversification strategies in maize cropping. Comparisons between monocrop maize and a series of rotations and agroforestry intercrops showed high economic and adoption potential for what researchers termed "semiannual perennials" (SP). The most financially viable and beneficial for ecosystem services was an SP rotation of pigeon pea (*Tephrosia vogelii*) and maize. This system performed well in countrywide trials, with high figures for value cost ratios (VCR=7.3-9.4), fertilizer efficiency (increased by 53 percent), percent plant cover (between 4-7 months), and protein yield values, as compared with three other systems. The benefits of this particular design include increased soil cover by the legumes, increased maize yields, increased synthetic fertilizer efficiency (when used) and increased protein content of the legume for human and/or livestock consumption. This system also showed a high level of preference from farmers. (Snapp, et al 2010)

In addition to introducing new strategies, technologies and techniques, programs that emphasize the design principle of *"stacking functions"* can maximize the potential of existing resources and find innovative uses for them as well as better leverage outside inputs to increase energy and nutrient potentials. "Stacking functions" starts from an in-depth analysis of *elements*, their *functions* and their contributions to various *yields* within a household or farm system. Assets and capital (financial, natural, productive, social and human) that currently exist as well as potential inputs would be considered the elements in the system. Each of these elements can serve multiple functions. For example, a camel, an element in pastoralist livelihoods, serves the multiple functions of providing milk, meat, transportation, income from milk or meat sales, waste products for fuel or fertilizer as well as acting as a savings mechanism and providing other intangible social benefits. A building can serve multiple functions – as a means for harvesting rainwater, generating microclimates in the sun or shade for crop diversification, and providing space for production on walls or roofs, etc. This analysis of common system elements in targeted communities will facilitate innovations to leverage existing resources efficiently by better ensuring that *every element in a system serves multiple functions* and that *every function needed in a system is served by multiple elements.*

Ensuring each function is also served by multiple elements creates redundancy in the system, thus preventing a total system breakdown in the face of hazards and leading to increased resilience. External facilitation that mainstreams an analysis of system elements into market-based programs is more likely to have a sustainable impact on optimizing productivity and increasing incomes. The essential principle at work here is that there are many elements existing in smallholder and household food systems that are yet to be utilized to their maximum potential – answers to questions regarding resource constraints are often, quite simply, right in front of our eyes.

Multiple Benefits of Agroforestry Tree Domestication in Cameroon

The World Agroforestry Center has implemented a program that seeks to support farmers to increase food security, incomes and agroecosystem diversification through domestication and propagation of native trees. One of the successes of this project was the selection of trees based on farmers' interests and existing knowledge, which was then complemented with locally adapted techniques for tree selection, propagation and nursery management. The program has been successful in increasing tree presence on farms, which has yielded the following benefits: 1) increased fertility and agricultural crop production, 2) increased nutrition through fruit consumption, 3) improved income through the sales of surplus crop and fruit production, and 4) agroecosystem and income diversification. (Asaah 2011 and Pye-Smith 2010)

Facilitating regenerative natural resource management: Many areas of the world are already seeing the dramatic effects of climate change, poor natural resource management, monocropping, resource extraction and globalized agribusiness on the productive capacity of land and profitability of agricultural livelihoods. In such areas, it is not possible for communities to survive if their current resource management and agricultural systems are merely sustained. This is due not only to the loss of human adaptive capacity in the face of creeping ecological shocks, but also to the stripping away of the adaptive capacities of the biophysical system itself. At best, these systems have not been maintained to their potential, and, at worst, they have been actively degraded and depleted. Thus, in many program areas it is important to think in terms of regeneration as a first step in achieving sustainability.

Farmer Managed Natural Regeneration

Farmer Managed Natural Regeneration (FMNR) was first applied at scale by Tony Rinaudo, World Vision Australia's natural resource advisor, in Niger. The practice relies on pruning and coppicing techniques, as well as behavior change in animal grazing, to regenerate indigenous trees and shrubs from their stumps and root bases in order to achieve rapid growth. Farmers practicing FMNR in Niger have seen increased crop yields, fodder production, fuel wood availability from pruning and thinning, and the potential to sell firewood in drought. Studies have shown that FMNR has increased the vegetation on over 30,000 km^2 of land in danger of desertification in Niger, and the practice has now been introduced in Chad, Burkina Faso, Mali and Ethiopia. (World Vision International 2012)

Read about FMNR in World Resources Institute's report "Roots of Resilience" or **watch** FMNR in practice.

Given the current conditions faced by communities in the areas Mercy Corps and many other PVOs work, it is necessary to identify and develop innovative approaches that shift the focus from merely avoiding harm and sustaining the current status quo, to focusing on *regenerative agriculture* – an agriculture that renews the productive capacity of the agroecosystem and enhances the adaptive capacities of the land and the communities that manage it. Regenerative agriculture seeks to reverse the degradation of productive agroecosystems and accelerate a succession that increases both biomass and biodiversity, thus enhancing productivity.

Integrating local and scientific knowledge to leverage appropriate technologies: Agroecology emphasizes the need to integrate local and/or indigenous knowledge with modern science and technology to improve the use and management of natural resources and enhance access to markets and information. While there is no lack of availability of technology for improving production – mechanical, biological/genetic, chemical and IT – there is sometimes a disconnect between many of these technologies and their impacts on agroecosystem health as well as local cultural and economic contexts. In order for technologies to enhance resilience in food systems they must be "appropriate" ecologically, economically and culturally. They must "do no harm" to the agroecosystem and must be able either to be produced locally from local materials or to be made economically accessible for purchase and maintenance. Such technologies should also be culturally supportive, leveraging positive local knowledge and practices rather than undermining them.

Pro-Poor Sustainable Environmental Development

A Mercy Corps' project in Myanmar uses a market-driven approach to ensure a sustainable solution to energy poverty for vulnerable homes in the Ayeyarwady Delta – the region that was devastated by Cyclone Nargis in May 2008. The program has trained 22 local stove producers and equipped them with initial capital and materials to produce fuel-efficient stoves that have been selected for optimal thermal efficiency and emissions performance as well as tested for cultural acceptability. Fuel use has dropped by an average of **40 percent** among end users and thus improved agroecosystem health by reducing the demand on the degraded environment. The program has also used a market approach to establish tree nurseries and promote the planting of saplings and mangroves. To date, the program has planted **85,000 trees** that will provide valuable firewood and building material downstream in addition to acting as a buffer against future storms.

Market-based programming can be instrumental in making useful technologies appropriate to the local context by facilitating physical access to the technologies as well as economic access for households and communities that might not be able to afford such technologies and their maintenance. Additionally, while certain technologies may seem to be appropriate and indeed brilliant solutions to overcoming certain barriers in that they meet demands and are cost-efficient and ecologically sound, there may be intangible cultural barriers that make the promotion of such technologies difficult, if not futile. Solar cookers, for example, have largely failed to be taken up in communities where they have been introduced despite their potential to preserve the environment, to save households money on fuel and wood and to save women's time for other household and economic activities. The primary reason behind this failure is cultural – not only does food cooked over a fire taste different than food cooked by the sun, but there is also an intangible value placed on cooking by a fire, especially where women cook together in community. These values are often more important than the time and money saved through solar cookers making the technology difficult to adopt. The introduction of new technologies may be more successful when accompanied by behavior change and communications activities to sensitize communities on the use of the technology and its benefits.

Mercy Corps has introduced a number of appropriate technologies that have agroecological benefits while also improving household energy poverty, livelihoods and health. Some program examples include the promotion of fuel-efficient stoves in the Democratic Republic of Congo and Myanmar; market-based programs in Uganda and Timor-Leste to increase access to solar lanterns; and programs to improve household water quality through solar distillation in Tajikistan and bio-sand filters in Nepal and Ethiopia.

The System of Rice Intensification and Its Network

The ***System of Rice Intensification*** (SRI) integrates an agroecological approach for increasing the productivity of irrigated rice through specific management of plants, soil, water and nutrients. SRI management reduces plant-seeding density and focuses on establishing better quality transplants along with improved irrigation and soil management. The benefits of SRI have been demonstrated in over 45 countries, and include: 1) up to 50 to 100 percent or more increased yields, 2) up to a 90 percent reduction in required seed, and 3) up to 50 percent water savings. SRI principles and practices have been adapted for rain-fed rice as well as for other crops (such as wheat, sugarcane and teff, among others), with yield increases and associated economic benefits. In 2010, the SRI International Network and Resources Center (or SRI-Rice) was established at Cornell University and serves as a resource to support and document the implementation and evaluation of SRI worldwide. (SRI-Rice: SRI International Network and Resources Center 2014)

Mainstreaming climate analyses into agroecological assessments and design of optimal systems: Though climate change adaptation and disaster risk reduction are not explicitly called out in every donor's priorities for agriculture, food security and nutrition programs, incorporating analysis of the potential impacts of climate change, disasters and other agroecosystem disturbances into program design will support resilience of the communities we serve and the agroecosystems they depend on. Integrating these issues will add value to a long-term vision of the communities we work with. Countries with strong food security and agricultural programs and have called out these sectors as priorities, should make it a priority to understand current and potential future climate challenges. Analyzing historical climate data, understanding current impacts via perception of residents, and, when possible, identifying future changes via climate projections are all vital sources of information. Tools such as climate change vulnerability and capacity assessments can be helpful in translating this information into viable adaptation strategies. Building on climate analyses, countries can then ensure that proposed agricultural interventions address current and forecasted threats through layering Climate Smart Agriculture (CSA) practices into program design. CSA, as an approach, is built upon the principles of agroecology, with the intention of applying these principles specifically towards adapting to climate related risks to forests, fisheries, soils and pastoral agroecosystems. In addition to promoting land management practices such as *conservation agriculture*, CSA can further strengthen farmers' adaptive capacity by adding early warning systems for climate shocks, promoting crops which exhibit greater resilience to certain shocks and working with both governments and the private sector to improve social safety nets and risk insurance for protection against crop losses.

***Facilitating shared governance of natural resources**:* Shared governance of natural resources refers to an approach for the management of resources in which multiple stakeholders share power for making decisions regarding access, use, management and ownership of resources. Devolution, deconcentration and decentralization of natural resource governance is often necessary. In particular, decentralized governance of natural resources "is considered one of the key strategies for promoting sustainable management, equitable decision-making, promoting efficiency, participatory governance and equitable sharing of benefits accrued from exploitation of natural resources at the local levels. It entails the process of transferring some of the decision-making powers and responsibilities (fiscal, administrative, legal and technical) to sub-national institutions at the provincial, district, city, town and village levels" (UNDP 2006). Recognizing the distinct roles of traditional and informal governance structures in effective shared governance, devolution must align with traditional structures at the community level. The best applications of this approach will align governance with traditional management practices, consider current and historical conflicts and address power relationships between farmers (and pastoralists) and the private sector and governments. Furthermore, a long-term view so that short-term priorities are carefully balanced against long-term environmental impacts.

A 'Do No Harm' Approach to Building Resilience

As intensified production and increased profits are sought in agricultural livelihoods, extensive environmental externalities may follow. These include examples such as land degradation, decreasing water tables and quality, loss of biodiversity and the environmental and health impacts of excessive synthetic fertilizer and pesticide use. These "costs" to the households, to the agroecosystem, and to food security, nutrition and health are rarely accounted for in the market analysis and business models used to design agriculture programs. In conceptualizing resilience in food systems, it is essential to "get the equation right" when promoting strategies to convert natural capital to financial capital in order to ensure that such programming enhances, and does not compromise, nutrition and food system resiliency. Donor funding mechanisms that necessitate the design of two- to five-year programs and that demand impact within this time frame sometimes make it difficult to propose forward-thinking strategies that look 10, 20 or even 50 years ahead and ensure the preservation, building and regeneration of agroecosystems. In this funding environment, the strategies NGOs, donors and smallholders themselves turn to for shorter term results may risk undermining the longer-term health of agroecosystems and, potentially, the food security of smallholder farmers.

Multiple scenarios exist in which the goal of increased income and maximum yields in the short term may lead to more vulnerability in the long term and result in land degradation, reduction of production diversity, and the eventual decrease in redundancy and diversity in pathways to household food access. Examples of these potential pathways include the following:

- Shifting a focus to high-value crops at the expense of biodiversity and production for consumption
- Forestry practices that lead to deforestation, erosion and general land degradation
- Farming that extracts nutrients from soil without due diligence to replenishing them
- Farming that extracts water faster than water tables can regenerate
- Monocropping at the expense of crop diversity
- Establishing extension mechanisms that increase dependence on external input markets at high economic and ecological costs

Mercy Corps' *Environmental Screening Guide* states that "adverse environmental impacts would conflict with (our) commitment to the 'Do No Harm' principle. By ensuring we create no adverse environmental impacts we therefore support programs and remain true to core mission values." Commitment to these values may be further realized through the layering of agroecological approaches into context analysis and program design as well ensuring a 'Do No Harm' analysis is conducted while planning and implementing our interventions. Mercy Corps' *Agroecological Risk and Resilience Screening Tool* enables designers and implementers both in the field and at headquarters to better ensure that food security and agriculture support building resilience and avoiding harm in smallholder food systems.

As we consider the need for agroecosystem health in smallholder farmers' livelihoods over the long term, it remains clear that smallholder farmers and their families do also have immediate needs to secure food and incomes. Thus, strategies to improve food system resilience must be careful to not undermine already compromised household food and nutrition security in the short term. The debates surrounding the various trade-offs involved in increasing and improving productivity, feeding a growing world population, and doing so sustainably, are diverse, impassioned and often abound with a variety of views and priorities. As contributors on all sides of these discussions continue to offer solutions to the challenges facing agriculture and smallholder farmers, agencies concerned with resilience will benefit from undertaking context-specific inquiries into the relationships between food systems and the agroecosystems they depend on. This additional exploration will help to identify ways current and proposed interventions may leverage agroecological principles to increase resilience of smallholder farmers and avoid strategies which may otherwise do harm and increase vulnerability.

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