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SUSTAINABLE AGRICULTURE:
A NATIONAL PERSPECTIVE

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Public fears regarding possible contamination of foods with agricultural chemicals have combined with persistent concerns for soil conservation and water quality to make agriculture and the environment a major national issue. Fears related to Alar in apples and cyanide in imported grapes, for example, replaced fears of another drought in summer '89 news headlines. The Food Market Institute reported that 82 percent of food shoppers responding to a recent survey said that chemical residues in foods posed a "serious hazard" to their health (Steimel).

Many farmers also are concerned about their own health and the health of others, as evidence mounts concerning negative impacts of agricultural chemicals on the environment. Testing of farm wells used for drinking water have shown that a significant number of wells contain at least trace levels of fertilizer and pesticide residues. A recent report by the Agriculture and Law Institute indicated that 40 to 56 percent of the 568 farmers surveyed favored restricting fertilizer application in watersheds known to have a high risk of water contamination (Institute for Alternative Agriculture).

Even farmers who feel that current farming practices are environmentally sound are concerned about the future of a chemically dependent agriculture. Farmers realize that costs of pest control are rising as pesticides become less effective. Nearly 500 insects and 50 weeds have become resistant to pesticides over the past few decades (League of Women Voters). David Pimentel estimated that farmers have increased their use of pesticides more than 30-fold since 1945, while pest-related crop losses have continued to climb. The National Research Council issued a landmark report, Alternative Agriculture, in 1989 which gave instant credibility to those who had contended previously that an environmentally-sound and resource-conserving agriculture could be productive and profitable as well. That report also identified agricultural policy and a biased research agenda at land grant universities as major obstacles to achieving a more sustainable U.S. agriculture. Agricultural impact on the environment has evolved into a major public issue.

The Question of Sustainability

Much of the current environmental debate in farm press has centered on the concept of Low Input Sustainable Agriculture or LISA. Research and education projects identified as LISA projects have been funded in the last three federal budgets through the agricultural productivity title of the 1985 farm bill. Total funding for the 3 year period has amounted to less than $13 million. However, the LISA program has been the focal point of much of the public debate regarding agriculture and the environment, even though LISA funds amount to less than 1 percent of the total federal agricultural research budget (Smith).
Low Input Sustainable Agriculture (LISA) is a relatively new term, and thus has no universally accepted definition. However, LISA actually embodies two separate concepts: low input (LI) and sustainable agriculture (SA). These two terms are related but do not mean the same thing.

**Sustainable Agriculture**

A definition of sustainable agriculture is still evolving as a product of debate concerning agriculture and the environment. However, there seems to be a growing consensus that a sustainable agriculture must be made up of farming systems that are capable of maintaining their productivity and usefulness to society indefinitely. Sustainable systems must be resource conserving, socially supportive and commercially competitive as well as environmental sound (Ikerd).

Systems which fail to conserve their resource base eventually will lose their ability to produce. Thus, they are not sustainable. Systems which fail to protect their environment eventually do more harm than good, ultimately destroy their reason for existence and thus are not sustainable. Resource conservation and environmental protection are the ecological dimensions of sustainability.

Farming systems which fail to provide adequate supplies of safe and healthful food at reasonable costs will not support social progress and ultimately will lead to political disruption. Agricultural systems of communist Europe and China are prime examples of systems that were not politically sustainable. Systems that are not commercially competitive will not generate the profits necessary for financial survival of producers and thus are not sustainable. Social supportiveness and commercial competitiveness are the socioeconomic or economic dimensions of sustainability.

In the long run, there is no conflict between ecologic sustainability and economic sustainability. In the long run, farming systems must be productive, competitive, and profitable or they cannot be sustained economically. Also, systems must be ecologically sustainable or they cannot be profitable in the long run. Even in the short run, there is no conflict between ecology and economics from the standpoint of society as a whole. When all costs and benefits to society over time are considered social costs will exceed social benefits only for those systems that are also ecologically sustainable.

The potential conflict concerning sustainability arises between individual producers and society in the short run. In the short run, systems that are most profitable for individual farmers may or may not be sustainable. Also, sustainable individual farming systems may not be profitable in the short run.

In such cases agricultural sustainability may require government involvement. Government subsidies and penalties can be used to reconcile differences between private and social costs and benefits so farmers will find it in their self interest to make decisions that also are in the interest of society in general. Alternatively, government funded research and extension programs can facilitate development and adoption of farming systems that are both ecologically sound and economically viable.
Are current agricultural systems in the U.S. sustainable? This is the crux of the sustainability issue. Many farmers, commodity groups, and agribusiness firms argue that there is no evidence that our current system is not sustainable. They contend that U.S. consumers have the most abundant, healthful, and safe food supply in the world and that people are leading longer, healthier lives as a result of modern agriculture.

Environmentalists on the other hand argue that the evidence of environmental degradation, such as chemical residues in water supplies, is conclusive and it clearly indicates excessive use of synthetic chemical in farming. Consumer advocates argue that we can't wait for future cancer and other health consequences of consuming chemically-contaminated foods before we restrict their use.

Conservationists point to the non-renewable nature of soil, fossil fuels, and many water sources as clear justification for social constraints in resource use. These groups contend that delays in addressing the issue of the negative ecological impacts of conventional farming can only add to growing, possibly irreversible, risks to people and damage to our environment.

The current public debate is between those who would continue to emphasize productivity and profitability as a means toward the end of sustainability and those who feel that agricultural sustainability is threatened by current farming practices which waste scarce resources, degrade the environment and present unacceptable risks to consumers. Neither group is opposed to the objective of sustainability. They differ only with respect to the means of achieving sustainability.

Low-Input Versus Sustainable

The low input or LI part of LISA generally is associated with farming systems which rely less on external purchased inputs, such as chemical fertilizers and pesticides, and more on internal resources such as land, operator labor, and management (Rodale). There is no clear division or point of separation between low input and high input farming systems. Thus, lower input rather than low input might be a more appropriate term. Systems become lower input if they reduce their reliance on external inputs and increase reliance on internal resources. Higher input systems, on the other hand rely more on external inputs and less on internal resources.

Lower input systems may or may not be more sustainable than higher input, conventional farming systems. Lower input systems tend to be more resource conserving and environmentally sound than conventional systems. For example, lower input systems that use smaller amounts of synthetic chemical pesticides typically represent lower environmental risks than do higher input, chemical intensive systems.

However, major reservations and questions have been raised regarding the productivity or ability of lower input systems to support growing populations with safe, healthful, food supplies at reasonable prices and on their profitability and competitiveness with higher input systems (Ruttan).
Achieving lower inputs is not an end but rather is a means to an end (Shaller). Reducing reliance on external inputs is one means or strategy for achieving the end or objective of greater sustainability. However, reducing inputs may or may not be an effective means of achieving sustainability. Economic viability and ecological soundness are both necessary, but neither alone is sufficient, in ensuring long run sustainability.

**Sustainability Requires Survival**

Sustainable farming systems must be able to survive adversity. The Rodale Institute talks about five Rs of sustainable systems: resistance, resilience, regeneration, re-design and replenishment (Heart). Shocks and associated threats to survival are an inescapable aspect of the ecology and economics of agriculture. Sustainable systems may resist, absorb, recover, adjust, or be restored, but somehow they must be able to persist under conditions of periodic ecologic and economic adversity.

A sustainable farming system must be able to survive drought, floods, pest outbreaks, and other physical shocks to the ecological system. It also must be able to survive short-run economic losses due to periodic crop failures, depressed markets and rising input costs that characterize the agricultural sectors of most economies. Sustainable systems may be unprofitable at times, possibly even for extended periods of time, but they must be able to resist or recover from adversity.

Farming systems that are productive and profitable under favorable weather and market conditions may be highly vulnerable to adverse physical or economic shocks to the system. Systems that appear to be sustainable even under average conditions may not be able to survive during adversity. Such systems may not be sustainable in the long run, even though under average conditions they could be productive and profitable.

**The Issue of Sustainability**

The pursuit of competitiveness and profitability has driven U.S. farmers to greater reliance on external inputs. Competitive pressures have forced farmers toward greater specialization as a means to greater efficiency. Synthetic chemical fertilizers and pesticides have allowed farmers to abandon crop rotations and mixed livestock, cropping systems in favor of more specialized cropping and specialized livestock systems. Low energy prices also allowed economic use of larger, more specialized equipment and production facilities which encouraged greater specialization.

Increased specialization has allowed farmers to realize economies of scale in production, marketing and financing in their operations. Specialization has resulted in increased efficiency of farm operators' labor and management resources. However, specialization has meant greater reliance on synthetic fertilizers, herbicides, insecticides, and other external inputs.

The trend toward greater reliance on external inputs has not been limited to synthetic, chemical fertilizers and pesticides or non-renewable energy based inputs.
Specialization also has meant greater reliance on borrowed capital and hired labor, and on more specialized knowledge and management skills in the form of paid consultants.

Rising Costs of Specialized Systems
Efficiency gains from specialization have been generally recognized and widely accepted for centuries as an economic fact of life. However, the reliance of specialized farming on greater use of external inputs has raised significant economic as well as ecologic questions. First, there are growing indications of declining effectiveness of the technologies which support specialized systems.

Insects are becoming resistant to insecticides and require higher rates of application or new insecticides for control. New insects sometimes replace the old. Beneficial insects often are destroyed along with the pests requiring even greater reliance on insecticides at higher costs. The same types of problems are appearing for herbicides as new, more resistant, weeds appear after others are brought under control. In addition, herbicide carry-over and build up in some soils can cause problems with following crops.

Previously fertile soils have lost organic matter and natural fertility through monocropping or corn-soybean rotations coupled with removal of aftermath year after year. Lower organic matter has meant less ability to hold water and nutrients in root zones, meaning lower yields from a given level of water and fertilization or higher fertilizer and irrigation costs to maintain yields.

Other costs of increasing specialization are beginning to show up in the environment of farm families and farm workers. Health risks in handling pesticides, for example, have become a major issue in farm safety. These risks eventually translate into less effective pest control, higher labor costs, or greater health risks for family members.

Chemical contamination of farm water supplies is another emerging concern of farm families. This issue, as much as any other, has increased the awareness of farmers to the potential environmental hazards of chemically dependent farming. Until recently, the environmental costs of increased use of synthetic chemical fertilizers and pesticides were external to the farm or imposed on society in general. The health risks to farm workers and farm families are internal costs and thus command the immediate attention of farmers.

In short, current trends in fertilizer and pesticide use seem to point to an increasing cost of supporting specialized farming systems. Research is currently underway to validate or refute this hypothesis and, if valid, to evaluate its significance.

The Question of Resource Risks
Farmers who rely on external inputs and specialized farming systems for their economic well being are similar in many respects to countries, regions and communities that rely on specialization and trade for their economic well being. They gain from greater economic efficiency by realizing their competitive advantages. However, reliance on external inputs embodies risks -- risk that currently profitable markets will be lost and risk that inputs will no longer be
available at reasonable costs from external sources.

Perhaps the most graphic recent example of this type of risks was the reliance on U.S. crop producers on export markets for wheat, corn and soybeans during the 1970s. Many farmers borrowed large sums of money to buy additional land and buy specialized equipment to supply these potentially profitable markets.

Specialized farmers producing export dominated commodities were hardest hit by the financial crisis of American agriculture in the early 1980s. They had taken the risks associated with dependence on external inputs, including borrowed capital, labor saving equipment, chemical fertilizers and synthetic pesticides to produce for markets that were vulnerable to an unpredictable world economy.

Comparative advantage is a concept commonly used by economists to illustrate potential gains from specialization and trade (Ikerd, et al). The principles of comparative advantage show that maximum output can be achieved at minimum cost for a farm, a country, or the world if all producers specialize in producing things they can produce most efficiently relative to other producers.

However, few countries are willing to depend totally on any other country for their survival. Countries sacrifice potential gains from specialization and free trade to maintain some minimum level of economic security. Few regions, states or communities within countries seem comfortable with employment bases that are reliant on markets or input suppliers in places beyond their economic control or influence.

Countries, regions and communities recognize the necessity to specialize in order to realize their comparative advantages. The costs of self sufficiency are too high. However, they also are willing to sacrifice some level of economic gain from specialization to maintain a degree of economic security.

The costs of self sufficiency in farming also are too high. Farmers will continue to specialize to some extent and will use some external inputs. However, highly specialized systems are risky. They may not be resistant, resilient or regenerative and thus may not be sustainable over time.

In summary, farm policy may be required in some cases to make more ecologically sustainable farming systems economically sustainable as well. In some cases, research and extension of new technology may be required to develop farming systems that are both ecologically sound and economically viable.

However, there is a general tendency for economic and cultural trends that are logical at one point to progress beyond the point of logical adoption at a later point in time. This tendency is responsible for business cycles, commodity price cycles and cyclical social phenomena.

The trend toward input intensive, specialized farming systems may have gone beyond its logical point of progression. If so, many farmers may have an economic, as well as ecological, incentive to move toward more sustainable farming systems even with existing technology and existing farm policies.
Sustainable Strategies for Agriculture

The philosophical foundation of sustainability is found within the concept of agroecology. Agroecology is a synthesis of agriculture and ecology (Altieri). The fundamental purpose of agriculture is to enhance the productivity of nature in ways that favor humans relative to other species. However, for agriculture to be sustainable, it must be compatible with its physical and social environment.

Humans are seen as only one component of an essentially interrelated ecosystem. The ecosystem includes other people and societies as well as physical resources such as soil, water and air. Attempts to shift the balance too far in favor of humans over other species, or in favor of some people relative to others, or in favor of one generation relative to others may destroy the critical ecological balance and eventually destroy mankind.

Ultimately, sustainable agricultural systems must reflect the inherent interrelationships between humans and the other elements of the physical and socioeconomic environment. Thus, the objective of agroecology is to enhance nature rather than replace nature; to work with nature rather than conquer nature.

There are three basic strategies for developing more sustainable farming systems. The first is to increase input efficiency within specialized systems; the second is to develop more efficient diversified farming systems; and the third is to develop profitable markets for commodities that can be produced with fewer external inputs.

Increased Input Efficiency

Current environmental risks may be more a result of misuse than of use of external inputs. Some environmentalists contend that any use of synthetic chemicals in any amount in farming represents a unacceptable risk to the environment. However, the general public is much more concerned about measurable chemical residues in food and water supplies than about the fact that synthetic chemicals are used at all.

Some ecologists contend that specialized monoculture systems of farming are inherently unsustainable (Altieri). In a long term philosophical sense, this contention may be valid. However, the greatest current threat to sustainability seems to stem from conventional production practices which support specialized farming systems rather than from specialization per se.

Regardless of their longer run sustainability, current environmental and resource risks could be reduced through more efficient use of inputs in specialized farming systems. In fact, greater input efficiency in larger specialized operations quite likely represents the greatest potential for reducing environmental risk from farming over the next decade.

Increased input efficiency is possible with existing technologies. Application rates, timing and placement of fertilizer is one area for potential improvement in efficiency and sustainability. For example, nitrogen applied in the right amount at the right time at the right place will be used by the plant and will not contaminate water supplies. Wasted nitrogen contributes cost but no returns to the economics of
crop production. Thus, more efficient nitrogen application through soil testing, tissue testing, banding and split applications could increase the ecologic and economic sustainability of crop production systems.

Similar possibilities for greater sustainability exist for use of insecticides, herbicides and other pesticides even in specialized farming operations. Pesticides applied at the right time and right place may control pests more effectively at lower rates of application. More effective pest control at lower levels of use reduces environmental risks and increases economic sustainability.

Resource conservation also may be achieved through more efficient resource management. For example, efficient irrigation scheduling may reduce crop stress while cutting use of water and energy. More predictable growth may allow more effective use of fertilizer and other inputs as well. Reduced tillage can reduce soil loss and cut energy inputs without sacrificing profitability in many situations.

Some intensively managed systems may use more rather than fewer external inputs. Some reduced tillage systems may require greater use of pesticides, at least in the short run. However, greater input efficiency means fewer inputs per unit of output and less potential negative spill over of inputs into the environment. Thus, net gains in sustainability may be possible through greater input efficiency without changing basic cropping systems.

Diversified Farming Systems

The greatest long run promise for sustainability seems to lie with a return to more diversified systems of farming. Diversified systems are generally conceded to be more ecologically sound than specialized systems. However, questions have been raised regarding the economics of diversification. Diversified systems of the past were abandoned for specialization on many farms.

Gains from specialization are undeniable but are not the only route to greater economic efficiency. There are potential gains also from integration. The productivity of an integrated system can be greater than the sum of the products of the individual system components. This phenomenon is called synergism (McNaughton). Specialized systems sacrifice the potential gains from synergistic interaction among the various components that are possible with diversified systems.

An obvious example of synergism is the interaction between livestock and crop rotations which include high quality legume forage crops. Livestock adds value to the forage and recycle nutrients back to the soil in the form or manure. Legumes add nitrogen to the soil, break row crop pest cycles and provide feed for the livestock.

Livestock without high quality legume pastures may not be profitable. Legumes in rotations without livestock may not be profitable. However, integrated livestock, legume rotation systems may add profitability to the total farming operation. This is but one example of the potential synergistic gains from integrated farming systems.

Risk is another important, but often overlooked, consideration in
diversification. Risks may be far greater in a specialized farming operation than in a diversified farming system with the same basic level of uncertainty in each system component.

For example, assume that one farmer has four enterprises and that each has an equal chance of returning a positive $6,000 or negative $2,000 net return in any given year. His average return is $2,000 per enterprise or $8,000 in total. If they are all positive he will make $24,000 and if they are all negative he will lose $8,000. But, let’s assume that the enterprises are totally uncorrelated. Net returns from each enterprise move up or down independently of each other.

Now let’s assume that another farmer specializes in one of the four enterprises but produces four times as much of it as our first farmer. The second farmer has the same chance of making $24,000 or losing $8,000 in any given year as the first has of making $6,000 or losing $2,000 on that one particular enterprise because the second farmer produces four times as much of it.

Both farmers have the same long run average or expected net return, $8,000. However, the diversified farmer is far more certain of a positive return than is the specialized farmer. In fact, the variability of net returns from year to year will be only about one-half as great for the diversified farmer as for the specialized farmer in this case.

Risk reducing effects of diversification are even greater if enterprise returns are negatively correlated, but will be less if they are positively correlated. Statistically calculated variance relationships between specialized and diversified operations vary from case to case. However, the general relationship will hold: diversified systems yield more stable returns over time than do specialized systems. This is the foundation for the old saying: "Don't put all your eggs in one basket."

In summary, synergistic farming systems are made up of system components which complement, coordinate, correlate, conserve, and contribute. Such components complement by completing nutrient and water cycles to increase efficiency and reduce wastes. Such systems use land and labor efficiently through coordination of activities to keep all resources fully employed without overextending any. Low or negative correlations among farm system components ensure offsetting production and price risk characteristics which enhance stability and reduce financial risks.

In addition, diversified synergistic diversified systems conserve their resource base by combining components which address the multiple environmental and economic objectives of sustainability rather than exploitation of resources for unsustainable short run profits.

**Markets for Low Input Commodities**

The third strategy for greater sustainability is to find profitable markets for commodities that can be produced with fewer external inputs. The organic food market is an example of one such market. Organic farmers have been important advocates of more research and information related to agricultural sustainability. Consequently, the whole concept of lower input sustainable agriculture frequently has been identified with organic farming. In reality, organic farming is only one
example of one strategy for agricultural sustainability.

The significance of the organic food example is related as much to organic markets as to organic production methods. Few farmers can afford to adhere strictly to organic standards of food production unless they receive a premium for the commodities they produce organically.

Many farmers may be able to reduce chemical fertilizers and pesticides significantly without sacrificing profitability. However, total elimination of synthetic chemical inputs typically will result in higher costs of producing commodities for conventional markets. Organic farmers may choose their farming systems for ecological reasons, but the market premium for organic foods provides the necessary economic sustainability for many.

The organic food market is not the only potential market for commodities that can be produced with fewer external inputs. Several attempts have been made to gain consumer acceptance for beef finished on forage rather than grain. Such beef could be produced on diversified livestock-crop farms with increased use of forages in crop rotations. Diversified forage finished beef farms might well be more sustainable than row crop farms or cattle feed lots. However, the key is to success in market acceptance.

A fundamental market oriented strategy for sustainability is to avoid head-to-head competition with large, specialized operations that produce basic, undifferentiated commodities for price competitive markets. Success with this strategy hinges on finding a product for which consumer preference is based more on a subjective quality such as healthfulness rather than price; a product that is not readily adaptable to large, specialized farming operations; and a product that can be readily identified with ecologically sound systems of farming.

New markets may not provide sustainable farming opportunities for a large proportion of U.S. farmers over the next decade. However, such markets may be a means of survival for some who otherwise could not compete. More important, such systems could provide insights into the types of food-farming systems that will ultimately be required for true long run sustainability.

**The Key: Tradeoffs**

Tradeoffs are the key to decision making. Tradeoffs are the key to evaluating the sustainability of farming systems. Systems must be chosen which consider tradeoffs between ecologic soundness the one hand and economic viability on the other.

Tradeoffs between productivity from external inputs and productivity from internal resources are critical in achieving an acceptable balance between ecology and economics. Productivity from internal resources is the result of synergism achieved through integrated farming systems. Productivity from external inputs often reflects gains from specialization. These tradeoffs between gains from specialization and gains from synergism are critical in developing systems that are both economically viable and ecologically sound.
Tradeoffs between comparative advantage and resource risks are another critical consideration in balancing short run profitability with long run survival. Systems which are most profitable in the short run may be highly risky and unlikely to survive in the longer run.

There are potential costs associated with each potential benefit in all cases of significant choice. Choices related to sustainability are no different. In reality, the significant decisions that lead to a more-or-less sustainable agriculture will be made at the margin where the choices between ecology and economics are not clear cut.

Better decisions rarely result from systematically ignoring reality. Some see only the ecological aspects of sustainability. Others see only the economic aspects of sustainability. In reality, sustainability requires systems that are both ecologically sound and economically viable. We cannot change reality by ignoring it or denying it. We must deal with the tradeoffs between ecology and economics if we are to achieve a more sustainable agriculture.
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