Natural Farming Systems in the Asia-Pacific Region: Strategies for Sustainability

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Introduction

Historically, natural farming systems are not new to the Asia-Pacific Region. In the past, the strength and sustainability of agriculture was related to the adoption of natural farming practices that ensured a balance between biological species (including man) that inhabited the land and derived their sustenance without damaging their environment. Thus, by its direct and indirect influences, settled agriculture of the historical past was not as damaging as it has been in the recent times except in situations when wars, or natural catastrophes, such as damaging floods, devastating droughts and other disasters brought about by the unpredictableness of nature, disrupted the sustainable trends. The Asia-Pacific Region has a rich history with several civilizations that were vigorous and dynamic.

Natural agriculture blossomed through shifting cultivations, cropping systems, integrated farming systems, agroforestry systems and pastoral systems being among the more important. With the advancement of the civilizations, settled agriculture made it necessary to harvest nature's bounty. Thus, catchment preservation or the impoundment of water in large reservoirs and the development of intricate irrigation and drainage systems, coupled with soil and water conservation practices, extended and intensified the natural farming systems that prevailed in different countries of the region. Integrated biological management and nutrient cycling were in place although not identified in the surfeit of terminologies and acronyms that abound today. Interestingly, these systems, which were developed independently in widely diverse situations, had comparable basic principles even though they evolved under different cultures, religions, social organizations and beliefs. Often the same systems were found across the Asia-Pacific Region with variations only in crops, varieties, sequences, seasons and techniques of production.

However, during the past 100 years, natural agricultural systems came under pressure (partly because of historical changes and partly because of false perceptions for the achievement of rapid agricultural growth, production and prosperity) to shift toward intensive chemical-based farming systems. The deviation or, sometimes, the alienation from natural farming systems was caused by compelling reasons. What were they?

Consultations on "Technology Assessment and Transfer for Sustainable Agriculture and Rural Development in the Asia-Pacific Region" in December 1992 pointed out that the major challenges for the region were (a) the receding forest cover (1.4 percent annually between 1981 and 1990) and (b) soil erosion caused by water and wind. Sixteen percent of Asia's agricultural land is considered severely degraded and production increases during the last decades have been achieved at considerable cost to the natural resource base; productivity levels have plummeted in the high yielding production systems (APPARI, 1993). Contributing to the erosion of natural resources was the increasing population growth.

Population Growth

The Asia-Pacific Region has the world's largest population. By 1991, the population exceeded 3 billion and constituted 56.2 percent of the world's human population (FAO, 1988). Therefore, the developing countries in the region (about 25) have about 55 percent of the world's total population. The long history of the Asia-Pacific civilizations and the relatively high population growth rates (compared with other continental land masses) have made the region more vulnerable to agroecological degradation, reduction of natural forest cover, decline of biodiversity, pollution of the environment and a host of other problems that are barriers to the development of a more sustainable agriculture.

The arable and permanently cropped land accounts for about 25 percent of the world's total. Within the Asia-Pacific Region, however, the proportion of arable to permanently cropped land is estimated at only 18 percent which makes the situation even more bleak. Thus, the agricultural land per capita is smaller than in most other parts of the world and the intensity of its use is greater. .

The increase in population through the years has reduced the per capita land area that is available for agriculture. Thus, more and more smaller parcels of land were farmed at subsistence levels, sometimes more frequently and more intensively, in order to produce the food needed for burgeoning populations. Shifting cultivation cycles recurred more often with shorter fallow periods; cultivated areas were carved out of forests; shortages of fuel-wood were supplemented by animal dung, thereby denying its use for soil nutrient replenishment; and farming moved up the slopes to more marginal lands and ecologically-sensitive areas which caused erosion and led to barren land in the hills and recurrent flooding in the plains. Concurrently, the technology of farming moved towards the use of synthetic inputs (chemical fertilizers and pesticides) in order to boost yields instead of natural inputs such as organic manures and biological control of pests. Even in cash crop farming, which ranges from small farms or small holdings to medium and large sized plantations, the necessity to increase yields for the export market has led to a decline in natural mixed farming systems and a marked increase in monoculture systems that are maintained with large inputs of agrichemicals.

We cannot, therefore, consider sustainability in natural farming systems without addressing the issue of population growth. If the Asia-Pacific Region is to develop natural and sustainable systems, the primary strategy has to focus on reducing population growth rates in the cities and urban areas, as well as the rural areas which are dominated by the agricultural primary producers, i.e., farmers. Acceptable population growth rates or the attainment of a zero growth rate in the future, which would be elusive in many of the countries in the region, would help to improve the quality of life, lessen the demand for food, de-crease the pressures on natural resources and the environment, increase incomes, improve education and provide other benefits and improvements that would allow the development of sustainable agricultural systems.

Yet the task is monumental. Projections for Asia have estimated that food crop yields in equivalent cereals will have to reach 3.2 t/ha by the year 2010 on an average available land base of 0.9 ha/capita. This translates to a yield increase of 2.5 times greater than that which occurred between 1970 and 1990 (0.8 t/ha) (RAPA, 1993).

Introduction of Capital Intensive Technologies

We have reflected on the possible causes for the breakdown of previous natural systems. Perhaps the most obvious was the success of capital intensive farming in developed countries, which has been accelerating since the 1950's, and perhaps gave developing countries wrong signals or inappropriate cues for the development of their agricultural systems. We attempted to transfer or to adopt the technologies developed in the west with little success.

Next, we researched and adopted high input synthetic-based technologies. For example, in plant breeding we continued to develop high yielding varieties that were responsive to ever increasing levels of inorganic fertilizers (moving away from natural organics) and having plant types shorter in stature that produced less stubble or biomass for organic recycling. Thus, we imposed more pressure on the natural fertility as well as on the physical structure of our soils. In order to obtain maximum yields, the agronomists researched optimal levels of artificial fertilizers which led to the lesser use of natural organic materials.

Crop production specialists (including entomologists, nematologists, pathologists, weed scientists and soil scientists) recommended ever increasing levels of agrichemicals that resulted in many imbalances in the population dynamics of the micro-fauna and flora. These practices often destroyed the biocontrol systems that nature provides. Add to these the imbalances caused by irrigated agriculture and the destruction of natural forests (some primary in nature) in order to open more land for agriculture. Environmental problems such as erosion, salinization, pollution, and other degradative processes became serious concerns of society.

Perhaps we should be satisfied that different technical approaches have led to greater achievements in agriculture, helped developing countries in the Asia-Pacific Region to record an impressive growth in the production of food crops (prevent starvation), and record an equally impressive growth in production of export cash crops. However, the price for moving away from natural systems of farming to the more artificial high technologies of chemical-based intensive agriculture has been destructive in many ways. We are now concerned about health problems, economic hardships of farmers with consequent high cost of inputs and fewer subsidies, and environmental degradation of natural resources.

The Case for Natural System

The diversity of farming systems had its origins in the diversity of agroecological regions, cultural histories, racial backgrounds and religious prejudices, indigenous knowledge and skills and other interacting influences. If we exclude the many smaller ecological niches, natural farming systems generally fit into four major agroecological zones, namely, (a) the humid and sub-humid lowlands where the major systems are shifting cultivation (much less now) and plantations (tea, rubber, coconut), (b) irrigated and naturally-flooded areas where the major systems are based on lowland rice and irrigated farming of a variety of crops including aquaculture, (c) hill farming in the mountainous areas, and (d) dryland areas of uncertain rainfall which are usually devoted to sisal plantations, upland cereal based systems, and pastoral systems. In all four zones, horticultural systems (tree-based perennial fruits and short season vegetables) as well as grazing or pastoral systems are seen with greater or lesser degrees of dominance.

The diversity of all these factors, agroecological, cultural, religious, ethnic, traditional and personal belief, are associated with a variety of indigenous and tribal customs and historical migratory forces that have helped to evolve numerous traditional sustainable farming systems. During the past three decades, agricultural research in the Asia-Pacific countries has refined the traditional natural systems and has also given them many names that characterize their nature, i.e., shifting cultivation, intercropping, multiple cropping, relay cropping, agroforestry, sloping agricultural land technology (SALT), to name a few. Many research studies, scholarly articles, extensive reviews and the publication of proceedings of seminars, workshops, conferences, expert consultations and other deliberations have provided various strategies for natural farming.

Organic chemicals in agriculture mean different things to different people. The U.S. Department of Agriculture’s Report and Recommendations on Organic Farming (USDA, 1980) has described organic farming as a production system which avoids or largely excludes synthetic fertilizers, pesticides, growth regulators, and livestock food additives. The USDA Report indicates that to the maximum extent feasible, organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mineral bearing rocks and biological control to maintain soil productivity and structure, to supply nutrients, and to control insects, weeds and other pests.

Parr et al. (1983) have stated that most countries used their available organic materials for soil renovation and soil rehabilitation, which has led to physical and biological improvements, and thereby, to increased productivity. However, the replacement of organic materials with chemical fertilizers and pesticides, which were available in abundance and at affordable prices, and the resulting increased yields and profits, principally in the responsive cereal grains, contributed greatly to the decline in organic agriculture. Some significant changes associated with this trend include more intensive cultivation and soil tillage practices for weed control and seedbed preparation which rapidly depleted soil organic matter levels. Consequently, the importance of organic amendments for crop production and soil management was neglected and for some time, even forgotten. In due course, however, the agricultural soils in a number of developed and developing countries had begun to suffer serious degradation and decline in productivity because of excessive soil erosion, severe nutrient losses and sharp decline in stable soil organic matter levels.

The strategy in organic farming both with respect to technology generation and its use lies in a balanced approach. Sudden shifts from market-oriented, intensive, chemical-based agriculture to organically-based farming systems almost always involve some initial loss in production that could lead to widespread hunger and malnutrition, and increased poverty and social unrest. However, in a balanced approach, within the context of local agricultural development, windows of opportunity for organic diversification of agricultural production need to be identified and expanded without compromising yields and quality. In the Asia-Pacific Region, changes have to be made primarily within two dominant production systems, i.e., the small farm, which often operates at a subsistence level, and the market-oriented, export-based large plantations. This is not an easy task because many decades, even centuries, of land use or, more appropriately, land misuse have lowered the soil's production potential.

The Major Thrusts of Nature Farming

A glance at the major thrusts and adoption of technology generation have shown a variety of integrated strategies in four principal areas, namely, production systems, biological controls, plant nutrient substitution, and energy supplementation. A few examples will suffice to highlight the trends.

Integrated Production Systems

Crop rotation, intercropping, alley cropping, agroforestry and SALT (sloping agricultural land technology) have all shown the value of nitrogen fixation unless the systems are legume-based for nitrogen replenishment. Besides the N enrichment through fixation, leaf fall, pruning and lopping have been shown to increase soil organic matter levels, improve soil tilth, reduce erosion, reduce weed populations and provide better control of pests and diseases. For example, the use of loppings of *Gliricidia maculate* in coconut plantings in Sri Lanka has been found to substitute for 50 percent of the nitrogen requirement in experimental plots. Likewise, the return of rice straw to the fields has been shown to provide up to 30 percent of the nitrogen requirement and a substantial proportion of the potassium requirement of rice. another aspect of the integrated production system is "eco-agriculture" or "eco-farming" which brings about a fuller and holistic integration of crops, livestock, farm wastes and natural sources of energy (Merrill, 1983; Laird, 1992). Tree home gardens or forest gardens as sustainable agroforestry systems found in the humid tropical Asian countries are well known (Widagda, 1981; Soemarwoto, 1987; Perera and Rajapakse, 1991). Their sustainability is maintained by biological organic recycling.

Integrated Plant Nutrient Systems

Green manuring, farmyard manures (FYM), composts, livestock refuse, and leaf litter traditionally have been used under the holistic approach to farming where crops, livestock and forestry were integrated. Green manuring can substitute for 50 to 80 kg N/ha in rice. The benefits of long-term green manuring on improvement of soil properties and yield sustainability are well known (Swarup, 1991). Biomass and nitrogen contribution by green manure can be as high as 6.6 to 6.9 tons of dry matter/ha and 113 to 147 kg N/ha, respectively (Singh et al., 1992). Research has shown that for the dominant cereal crop (rice), organic soil amendments such as straw and green manures, and biological N-fixation by *Azolla* and other blue-green algae can substitute for much of the chemical fertilizer requirement. Nagarajah and Anrarasiri (1977) reported that 50 percent of the fertilizer nitrogen required for rice can be supplied by applying 9 t/ha fresh weight of *Tithomia diverslfolia* or *Gliricidia sepium*. Increase in rice yields of 450 kg/ha (47 percent) from application of FYM alone has been reported by Shinde and Chosh (1971).

In the Philippines, the use of compost has reduced the chemical fertilizer requirement by 50 percent; accordingly, rice yields have increased by 10 to 15 percent and vegetable yields by 30 to 50 percent. These results, although convincing, have emphasized the need for accelerated bioconversion research. One such study has shown that the use of *Trichoderma harzianum*, a fungal activator for rapid composting, reduced the time needed for curing and maturation of compost from 3 to 4 months to one month (Cuevas, 1991). The use of cellulolytic microorganisms to hasten the decomposition of organic matter in soil and in the composting process has also been recognized.

Intensification of research to identify good quality organic materials, efficient bioconversion methods, and effective microorganisms as microbial inoculants should be given a high priority.

There is growing interest in the use of biofertilizers because of their apparent benefits in organic farming. Their development is more recent when compared with traditional organic fertilizers. However, from an evolutionary standpoint, they have been in nature be-fore the beginning of settled agriculture. The influence of *Rhizobium*, *Azotobacter* and *Azospirillum* have been extensively documented (RAPA, 1988). The use of *Rhizobium* inoculants in various leguminous crop production systems has become a standard practice. Heterotrophic N-fixing microorganisms in rice fields are also known. Their N-fixation rates are about 10 kg/ha compared to 60 kg/ha for *Rhizobium* in legumes. Likewise the use of *Azolla* is a standard practice in some countries such as China where 50 kg N/ha could be fixed while 30 kg N/ha is reported with the use of blue-green algae. Long-term experiments in the Philippines have demonstrated symbiotic N-fixation of 70 to 110 kg N/ha in wetland rice (Watanabe and Ventura, 1992).

In addition to these N-fixing microorganisms, the recognition of phosphate solubilizing microorganisms, including bacteria of the genera *Pseudomonas* and *Bacillus* and fungi of the genera *Aspergillus* and *Penicillium*, widens the scope of biofertilizers in addition to the previously known vesicular arbuscular (VA) mycorrhizal fungi which can enhance the uptake of soil phosphorus by plants. The technologies for use of biofertilizer aids such as BNF, *Azolla*, and blue-green algae are available. However, greater efforts are needed to identify effective microorganisms that would help to gradually replace costly chemical fertilizers.

Integrated Pest Management Systems

The integrated pest management (IPM) systems are an extension of natural farming activities whereby mechanical, cultural and biological manipulations make farming less dependent on chemical control measures. Because of concerns for environmental pollution and escalating costs of imported agrichemicals, countries in the Asia-Pacific Region have researched, identified, and utilized biological control measures. Their success is evidenced by control of the sugarcane leaf hopper (*Pyrilla perpusilla*) in Pakistan and India with an insect (*Epiricania melanoleuca*) (Mohyiddin and Hamid, 1988). An equally successful report on biocontrol of *Pyrilla perpusilla* in sugarcane was reported in Sri Lanka using a parasite (*Tetrastichus purillae*), which destroys the eggs, and also using two types of fungi (*Metarhizium anisopliae* and *Phasiolimysis lilacinas*) that attack both the young and adult *Pyrilla*. Success is achieved by stubble mulching cane tops during harvest instead of burning them, a practice that removes the breeding sites of the parasites, causes loss of soil nutrients, and increases environmental pollution.

Similarly, the use of shade trees (*Gliricidia sepium*) has demonstrated the reduction of shot hole borer incidence in tea production. In this case, the lopped ends of *Gliricidia* branches that suffer from die back and rot become very attractive to swarming termites, thereby diverting the swarms from pruned tea branches to them. There they lay eggs, and when the eggs hatch the termites are killed by some toxic substance. *Gliricidia*, therefore, serves as a diversionary host and as a trap crop. The status of IPM in the Asia-Pacific Region has been evaluated at recent conferences (Ooi et al., 1992). These examples provide hope for the adoption of natural systems of control.

More recently interest in the development and use of bio-pesticides has been renewed. Bio-pesticides control or eradicate diseases, pests or weeds in which the active ingredient or principle is based on a living microorganism such as a bacterium, fungus, virus, nematode or protozoan. The major product group is based on *Bacillus thuringiensis* (Bt). Although the development of this approach and its use is still in the west, the technology will likely be applied soon in the Asia-Pacific Region.

Biofuels In Natural Farming Systems

It is obvious that natural farming systems cannot be separated from their potential for generation of biofuels and other forms of energy. Many countries in the Asia-Pacific Region are highly dependent on fuel wood for heating and cooking. Deforestation, which has reached alarming proportions, and extensive use of other biologically-derived sources of energy, such as agricultural residues and animal dung for fuel, might seriously jeopardize agricultural sustainability in the future. The strategies of the farming systems approach allow reversal of the process in ecological situations and communities where a fuller integration of crop-1ivestock, and crop-livestock-agroforestry combinations can be adopted. In other situations, the exploitation of wind and solar energy adds another dimension to natural farming and sustainability. Many constraints have been identified that prevent large-scale adoption of natural energy sources. But these are not insurmountable with proper planning, feasibility studies, and assessment of techno-socio-economic conditions. Additional research support is needed to make energy sources affordable and available.

Biodiversity for Natural Farming System

"Harvesting Nature's Diversity," the theme of the FAO World Food Day, reminds us of another strategy for sustainability in the form of germplasm conservation for future agricultural use. For too long, we have allowed our genetic resources to erode at a rapid rate, not recognizing their potential and unconcerned about their loss. In India alone, very soon only 10 varieties of rice will be planted in an area where once over 30,000 different varieties were grown. Across the Asia-Pacific Region, the dependence on such a narrow genetic base in crops and livestock and the loss of masses of indigenous genetic material, together with the traditional knowledge and skills of the indigenous people who selected, bred and nurtured them, is a major concern we cannot ignore.

Of the thousands of edible plants only a few hundred are used for human food and nine of the most important species, namely, wheat, rice, maize, barley, sorghum/millet, potato, sweet potato, sugarcane and soybean, provide 75 percent of the plant kingdom's contribution to human energy. They are all grown in the Asia-Pacific Region under different agroclimatic regimes. Their genetic conservation as well as the under-exploited and unexploited species of potential use for farming systems of the future should be of paramount importance.

Of the 20 major plant gene banks in the world only 4 are located in the region. But other, small genetic resource centers are found in many countries. However, more emphasis has to be given to expansion of several of the lesser known gene banks in order to increase their capacities. Their inventories will no doubt contribute to the sustainability of agriculture. Even in livestock production, where the goals of improvement focus on increasing productivity, it is now realized that the production systems, which led to this restricted goal, are not sustainable. Besides, many drawbacks such as high cost, environmental contamination, soil erosion, and stress on man and animals, the increasing emissions of methane (perhaps the most damaging of greenhouse gases) may be linked to large numbers of farmyard ruminant animals. Furthermore, overstocking with grazing animals has also contributed to soil erosion in both the arid and humid tropical zones.

Preston and Murgueitio (1992/93) have proposed that the identification of high yielding, sustainable ecosystems must be the first step in any attempt to design new systems. They state that the products of such ecosystems must be able to serve as the principal inputs for integrated activities. Thus, using commodity species such as sugarcane, natural biodiversities such as the multipurpose tree species (MPTS), and water plant subsystems with swine and duck integration are possible approaches to the farming systems concept.

The objectives of such farming systems are to keep the whole environment friendly and sustainable, building on the twin concepts of eco-development and self reliance. Here all the requirements are farm-based with little fossil fuel input, and in the process, a surplus of biomass energy is also provided. The development of such farming subsystems based on this approach is attractive to resource poor farmers and should contribute to the future stability of agriculture in the Asia-Pacific Region.

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