Research and extension strategies for resource-poor farmers; farming systems versus biotechnology

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Abstract

"The sun provides us with more energy than we will ever need". So runs a recent advertisement on the back cover of the July issue of the journal "Renewable Energy World" (Shell, 1999). As well as providing energy to replace that presently derived from fossil fuel deposits and nuclear sources, the sun can also provide the energy needed to produce the food required for a world population expected to double by the year 2050. The challenge is to capture the sun's energy in systems of production and utilization which at the same time will contribute to alleviation of poverty, creation of jobs, a more equitable life-syle, protection of the environment and increased biodiversity. It is argued that an approach based on maximising use of natural resources in integrated farming systems is more appropriate for achieving the above objectives than focusing on increasing the yield capacity of individual species in specialised crop and livestock production systems.

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Introduction

The Farming Systems Research movement is relatively recent and has been promoted by scientists from diverse disciplines who considered that agricultural research was becoming too reductionist and compartmentalised. It was felt that the real objectives of agricultural research were being overlooked by the obsession with increasing the productivity of individual elements and that the holistic nature of farming was being forgotten. In fact, the concepts behind FSR are as old as agriculture itself and have been practised by most of the individuals who have made major contributions to agricultural development during the last century. So the question is raised? Why has it been found necessary in relatively recent times to promote what, to many of us involved in agricultural development, appears to be obvious.

One of the reasons is that there has been a major change in the background of people who have elected to do agricultural research and extension. In the decades from the 30s through the 50s the majority of scientists taking up research and extension as a career came from a farming background, and even if not raised in a farming family, it was an essential part of their degree training that they spent at least one year working on a farm. From the late 50s onwards this situation began to change with the increasing pace of farming mechanisation, the onset of. corporate farming and urbanisation. Discipline-specific research required discipline-specific teaching. In many universities, schools of animal and crop husbandry were transformed into faculties of animal and crop science. The multi-faceted family farm became a specialised enterprise and the marriage of livestock and crops, which made agriculture productive and sustainable in the early part of the 20th century, broke down as the agrochemical industry began to provide the inputs previously only obtainable through the practice of good "husbandry". The short-term success of the "Green Revolution" in the 60's and 70's appeared to offer further proof that crop production could indeed be divorced from livestock. For their part, the livestock scientists – freed from having to consider the multi-purpose traits of livestock, such as draught power, manure production, capacity to scavenge for their feed supply – concentrated most of their efforts into increasing the capacity of animals to produce marketable goods such as meat, milk and eggs.

The fossil fuel crisis in the late 70's was the first warning of the dangers inherent in an agriculture dependent on fossil fuel-derived inputs. The negative effects of the Green Revolution also began to surface in terms of increased soil salinity, erosion through deforestation to increase cropping areas, and resistance of plant pests to agrochemicals. The World Commission on Environment and Development (Brundtland *et al.*, 1987) was a manifestation of the increasing awareness that the earth's resources were finite, and that a purely technological approach could not resolve problems that had their origins in sociological and environmental issues.

These are some of the events that, in the 80's, gave rise to the movement loosely referred to as the Farming Systems Approach (FSR) and which became institutionalised in the formation of various Associations for Farming Systems Research-Extension. Many scientists that were trained in the 40's and 50's , myself amongst them, often found it difficult to understand the enthusiasm for FSR. Having been raised in close association with mixed farming systems, and retaining the awareness of the nature of the farm community as the target group, the FSR appeared to offer little that was new other than providing a terminology for the strategy that the older generation of applied agricultural scientists had used traditionally in their work. A further criticism was that the methodological features of FSR started to become the dominant feature of this paradigm. Proponents of FSR appeared to spend more of their time in the development of the methodology than in the development of technologies which could benefit the farmer.

Table 1 Projections of food producing capacity of the earth for 2050

	1989	2050	Increase %
Cultivated area, % potential	0.3	0.38	20
Cropping frequency, Crops/yr	0.87	1.04	20
Yield, tonnes grain equiv/ha	2.24	4.5	100
Import factor	1.03	1.08	5

Source: UN 1996.

In the 90's some of the issues that gave rise to the birth of FSR began to attract more specific attention with the advent of Rapid Rural Appraisal (RRA) and later Participatory Rural Appraisal (PRA), under the dynamic leadership of Robert Chambers (Chambers, 1983; Chambers & Ghildyal, 1985). However, as with FSR, the new paradigm of PRA appears to be addressing the same basic issue - of giving priority to understanding the needs of the farmers and tailoring the research and extension so as to respond adequately to those needs. Unfortunately, to my mind, the proponents of PRA have tended to follow the same path as their predecessors in FSR with the “tail beginning to wag the dog”. PRA methodology has become paramount yet many of its practitioners fail to appreciate that it is not enough to diagnose the needs of a farm family or farming community. The diagnosis must lead to a solution. And here is where we have the great dilemma. The sociologists rightfully insisting on moral issues: poverty, equity, employment, the environment and sustainable use of resources, but having few means at their disposal that could lead to a solution. The technologists on the other hand, led by the knights of gene modification, claim that they can solve all the world’s problems if only they are given the absolute freedom to pursue their branch of science. And like a shadow looming over everyone and everything, is globalisation with the potential to do both good and evil. The danger is that both technology and globalisation will inevitably lead to an acceleration in the rate of utilization of natural resources and the rate of loss of diversity. A way must be found in which productivity is raised not simply by raising the genetic potential of existing cereal grain crops, where most effort is presently directed, but by adapting the farming systems so as to maximise the use of the existing natural resources of solar energy, soils water and people for multiple end purposes

What should be the role of research, training and extension in these processes and what should be the strategy in order to respond to the challenges that face us? Agriculture has an important role to play: as a source of food, energy, employment and the contribution it can make to quality of life. This latter issue was raised in the recent Reith lectures in the UK, when the Prince of Wales made an impassioned plea for society to take on values more closely related to natural processes. Hodges (1999) lamented the divorce that has taken place between people and animals and blames this separation for many of the ills that plague society, particularly in the “so-called” “developed”. The polarization of scientists over the implications of gene modification (Mae-Wan Ho, 2000), the outright opposition of UK consumers to GM foods and the demonstrations in Seattle and Washington over the effects of globalization, are proof that all is not well in the technological world.

It is relevant to set out the basic issues which bear on agricultural activities. These are:

$ The close to doubling of the world population before it stabilises at around the 9 billion mark in the mid-term of the century
$ The increase in people's aspirations as the world economy continues to grow.
$ The decline of oil as the staple energy source.
$ Increased concern for issues related to animal welfare and use of agrochemicals and pharmaceuticals in agriculture

The first two developments will result in increased needs for food and energy and for greater dietary diversity which will especially increase the demand for animal products (Table 1 and Figure 1). The eventual decline in oil supplies (Figure 3) will force up prices with two consequences of direct concern to agriculture:

$ "modern" methods of crop production, especially of cereals, will face a serious increase in costs (Figure 4) ;
$ there will be increased opportunities to develop sources of renewable energy

Food production

The World Food Summit convened by FAO in Rome in 1997 predicted that food and feed production in developing countries must be tripled by the year 2050 to cater for the demand created by the expected doubling of the human population and their increasing aspirations for a higher standard of living.

The means that were proposed to meet this target (Table 1) were justified on the basis of linear projections of world production data over the last 4 decades which indicated that such increases in productivity were feasible.

More recently, a group of economists from the International Food Policy Research Institute, FAO and the International Livestock Research Institute (Delgado *et al.*, 1999) coined the term "Livestock Revolution") on the basis of their predictions that demand for meat in the developing world will double by the year 2020 (Figure 1) with an even greater increase for milk. Their proposal as to the means by which to achieve these targets was through increased use of cereal grain as animal feed (of the order of 300 million tonnes annually; Figure 2); and that the grain would come mainly from the "traditional grain exporting countries" (i.e. North America and Australia). The required increase in grain production was estimated to be 1.4% annually.

Figure 1: Projected demand for meat in 2020 (Source: Delgado et al 1999)

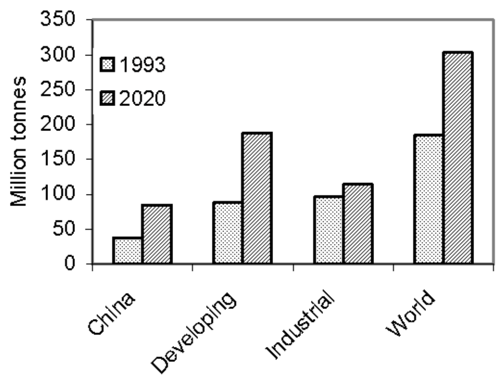


Figure 2: Projected demand for cereal grain as animal feed in 2020 (Source: Delgado et al 1999)

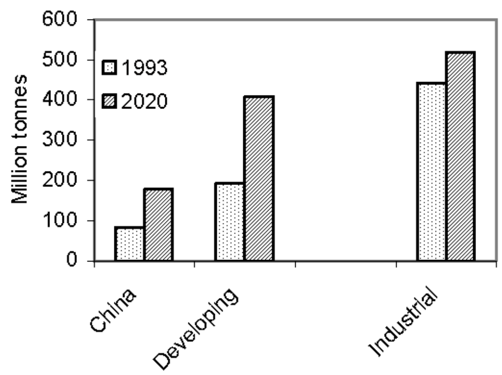


Figure 3: Trends in production of commodities; periods of rapid (1950-85) and slow (1986-92) growth (Source: Brown and Kane 1994)

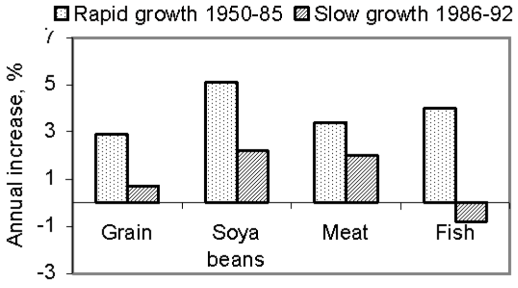
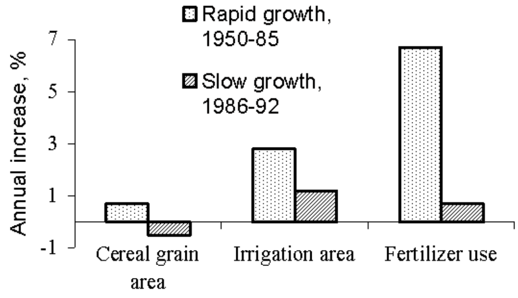


Figure 4: Trends in availability of agricultural resources; rapid (1950-85) and slow (1986-92) growth (Source:Mai Kim Dinh 1995, unpublished)



Aside from the socio-political issue of whether such “dependency” of developing nations on the developed ones is desirable, there is considerable doubt about the technical and economic feasibility of achieving such an increase in grain production (for comparison the present annual maize grain production in the USA is of the order of 200 million tonnes). A close examination of the basic data reveals that the trends in food production over this time phase are not linear. In fact, two trends should be fitted to these data. The first describes the high growth period from the ‘50s to the ‘70s (the time of the “green revolution”) and the second relates to the post “green revolution” era (Figure 3) when rates of increase in major food commodities declined markedly (and were even negative in the case of fish) to levels which will not sustain the proposed needs (Brown & Kane, 1994). Rates of increase in production have declined because of reduced areas under cultivation and reduced inputs, especially of fertilizers (Figure 4), due to marginal yield responses to inputs as crop production rates reach their biological limits. It must also be recognised that intensive cereal grain production is heavily dependent on inputs derived from fossil fuel (Figure 5).

For every 18 MJ of the food energy in 1 kg of rice produced in the USA the input in fossil fuel-derived inputs is 12 MJ ... approximately two thirds. By contrast, the fossil fuel needs in traditional rice production in Asia and Latin America are little over 10% of the energy in the grain. Fossil fuel supplies are presently at their peak level and will begin to decline in the next century (Figure 6). Prices will inevitably rise, which will have serious consequences for cereal grain production particularly in the industrialized countries in temperate latitudes, which are the major cereal producers.

Figure 5: Fossil fuel cost of grain production (Source: Pretty 1995)

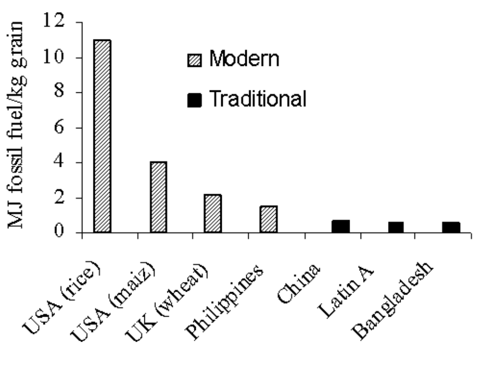
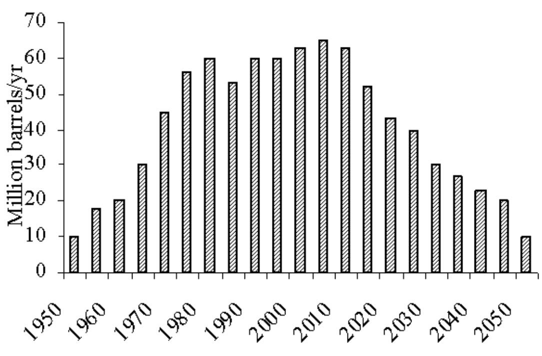


Figure 6: Trends and predictions in oil supplies (Source: Campbell 1997)



An alternative approach

What can be done to meet the food needs of the doubled world population without concomitant increases in cereal grain production and resultant negative effects on the environment? The approach should be based on:

$Selecting and promoting crops and farming systems which optimize use of natural resources without depleting them

$Matching the production system with the available resources

$ Recognizing that poverty, and not food, is the major constraint to equitable development

The present livestock production systems in most industrialised countries (New Zealand and parts of Australia are the exception) are directly in competition with human needs. Livestock presently consume almost 50% of world cereal grain supplies (Sansoucy, 1998). In the “intensive” large scale production systems, increasingly promoted by corporate agriculture, livestock wastes contaminate soil and water resources, create less than favourable working conditions for the personnel involved in feeding and cleaning, and decrease employment opportunities.

The solution to the problem of meeting food needs in 2050 is to develop livestock production systems, which do not depend on cereal grain. Feeding grain to livestock is a recent phenomenon. It is neither necessary nor desirable. Alternative non-grain systems will lead to reduced contamination of the environment, increased employment opportunities (for families), enhanced biodiversity and better quality of livestock products.

Selecting and using non-grain natural resources for livestock production

Energy crops

In tropical countries where population growth is concentrated, there are many crops and farming systems that considerably exceed the productive capacity of grain cereals (Figure 7).

Key plants in this scenario are:

$Sugar cane

$Cassava

$The palm family especially the Oil and Sugar Palms

The yield potential of the sugar palm (*Borassus flabellifer*) is extremely impressive. An annual average yield equivalent to 18 tonnes of soluble sugars per hectare has been documented in a study with 12 family farm households in Cambodia (Khieu Borin & Preston, 1995). Yet despite this demonstrated potential almost no research is currently conducted to improve the technology of growing and using this tree, which is found throughout the SE Asia region.

Figure 7: Grain equivalent yield of temperate and tropical crops

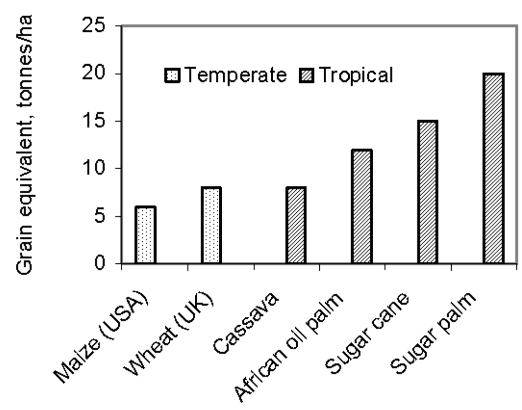
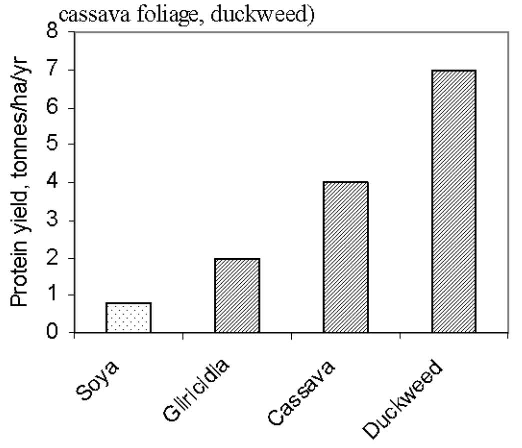


Figure 8: Protein yields from temperate (soya bean) and tropical crops (Gliricidia, cassava foliage, duckweed)



Protein crops

There is an equally great potential to produce high yields of protein in the tropics. But this will be with trees and shrubs and water plants... rather than with soya beans (Figure 8).

The Lemnacaea, of which "duckweed" is the most widely distributed, have a particularly important role to play in efficient resource utilization because of their capacity to extract nutrients from water fertilized with wastes (excreta) from livestock and people (Leng, 1999). A specific feature of this plant is that its protein content can be manipulated according to the nutrient supply in the water (Figure 9). Values in the range of 35% to 40% protein in the dry matter can be attained when the nitrogen content of the water is in the range of 20 to 30 mg/litre (Leng, 1999). Duckweed is easy to harvest and needs no processing prior to being fed to livestock. The protein is highly digestible and the excellent balance of essential amino acids makes it an ideal supplement for chickens, ducks and pigs (Bui Xuan Men *et al*., 1996; Rodriguez & Preston, 1997; Nguyen Duc Anh & Preston, 1998). Average yields are of the order of 100 g fresh biomass/m²/day equivalent to up to 8 tonnes of protein/ha/year (Figure 10).

Figure 9: Effect on N content in pond water on protein content of duckweed (Source: Leng 1999)

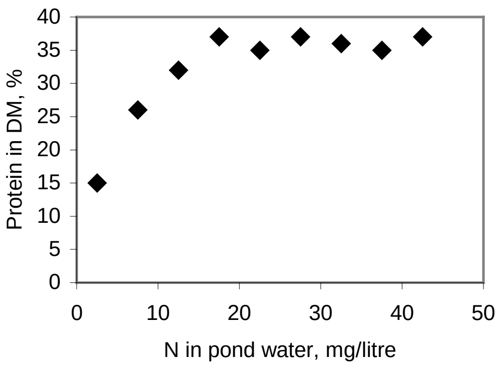
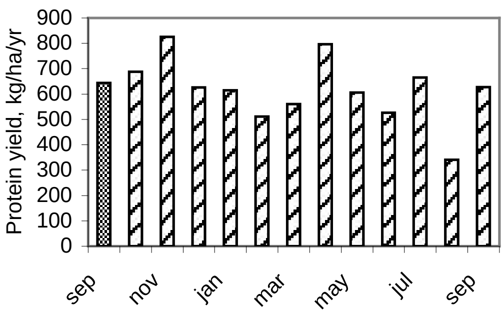
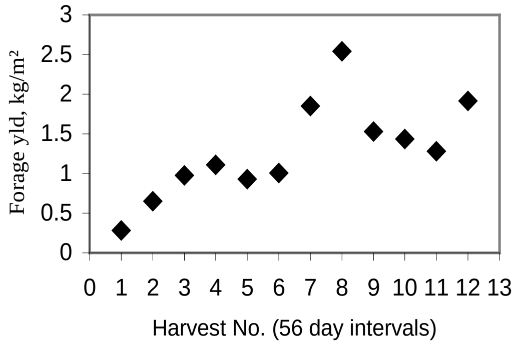


Figure 10: Protein yield through a one year cycle from duckweed grown in ponds fertilized with biodigester effluent (Source: Nguyen Kim Khang 2000)



The cassava plant (*Manihot esculenta*) can be managed as a perennial forage crop with repeated harvests of the foliage at 50-70 day intervals. The foliage yield increases over successive harvests (Figure 11) as the repeated cutting stimulates new growing points. Yields of 3-4 tonnes of protein/ha/year are possible with this regime.

Figure 11: Forage yield (fresh biomass) over two year period from cassava managed as a perennial shrub and fertilized with goat manure (Source: Preston et al 2000)



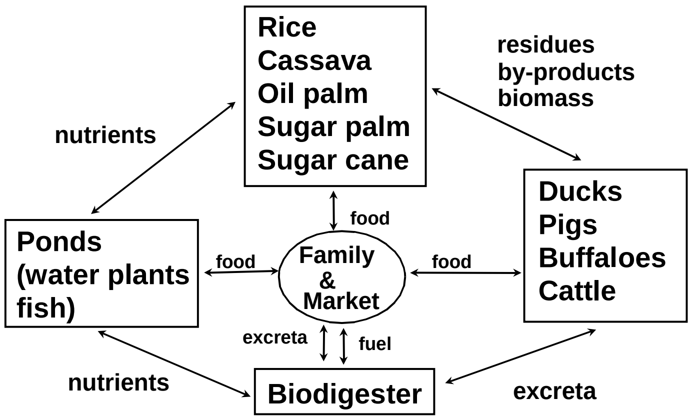
The fresh foliage is an excellent protein source for ruminants (Ffoulkes & Preston, 1978), while after ensiling (which converts the toxic cyanide into non-toxic cyanates) it can safely be fed to pigs (Du Thanh Hang, 1998). Cassava is an exploitive crop when grown in monoculture and on sloping land. Managing it as a perennial shrub / tree and associating it with N-fixing legumes, such as *Flemingia macrophylla* or *Desmanthus virgatum* (Khieu Borin & Lylian Rodriguez, unpublished data), or fertilizing it with heavy dressings of livestock manure or biodigester effluent (Le Ha Chau, 1998) are ways in which it can be grown sustainably with enhancement of soil fertility. The presence of the cyanogenic glucosides in the leaves appears to serve as an "organic" pesticide apparently providing protection against a wide range of pests.

Changing the livestock system

The feeds derived from these "alternative" crops (juice from sugar cane and sugar palm, roots of cassava, fruit from oil palm, duckweed biomass and cassava foliage) do not lend themselves to "factory" farming systems which traditionally use dry feeds easy to store, transport and mix into "least-cost" rations. The "alternative" feeds require "alternative" farming systems. These will be small scale and highly productive. They will be diversified and integrated (Figure 12) and the role of animals in these systems will be synergistic rather than as primary producers. Emphasis will be on "small" livestock.

Primary beneficiaries of these systems will be women and children, who will benefit from biogas technology (cleaner cooking utensils and smokeless kitchens) and the merging of family and farming activities. External inputs will be minimised through waste recycling, and growing of nitrogen-fixing and pest-resistant plants in the farming system. Biodiversity will be enhanced as the "alternative" feeding systems, using mainly local plant resources, will provide comparative advantages to indigenous animal ecotypes (Rodriguez & Preston, 1997) and opportunities for greater use of indigenous knowledge.

Figure 12: The integrated farming system



Information technology

There are strong vested interests that favour corporate (large scale) investment in, and management of, agricultural activities, despite the evidence that small-scale family farms are more productive and are socially desirable (P.M. Rosset, 1999, personal communication). The rejection by consumers in Europe of foods derived from genetically modified crops highlights the importance of access to information. It was the public debate about "GM" foods that resulted in the reaction from consumers.

The rapid development of cellular phone technology, especially in poor countries (Quadir Iqbal, 1999), coupled with global linkages via the Internet, is an opportunity for rural communities to have access to relevant knowledge and to share in the multi-media activities previously available only to urban dwellers. Initiatives such as the Village Information and Training Project (VITP) advocated by FAO and IFAD (Andrew Speedy, unpublished data) and the Village Knowledge Centres presently being promoted by the Swaminathan Research Foundation in India (K. Balasubramanian 1999, personal communication), should be strongly supported because of their potential impact in "levelling the playing field" between rural and urban communities. They are appropriate for ensuring that families engaged in small scale integrated farming systems have equal access to information and learning opportunities as those in the corporate farming sector.

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