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The System of Rice Intensification: An Alternate Civil Society Innovation

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A major strategic decision for meeting global food needs is whether this should be attempted by continuing along the current technological trajectory, or whether divergent paths should be considered. Trends such as shrinking arable land per capita, growing water constraints for agriculture, higher energy and production input costs, and the need to preserve environmental quality give impetus for an agro-ecological approach to sustainable production intensification in which biological processes are utilized to enhance factor and total productivity. The "System of Rice Intensification" (SRI) developed in Madagascar has been demonstrating substantial productivity gains and other benefits through making changes in crop, soil, nutrient, and water management, rather than from introducing new varieties or increasing external production inputs. The scientific controversy over SRI should subside as increasing evidence supporting its claims gets accepted into the published literature.

1 Introduction

The challenge of meeting global food demand in the decades ahead raises a question of strategy: To what extent can this goal be met by doing "more of the same" – by simply continuing along the present technological path and finding better solutions in this direction? Posing this question raises a corollary query: Should we be charting some new avenues to increase food production?

These questions do not presume that there will or can be a wholesale shift to alternative methods of production; this will not in any case be practical or feasible in the short to middle run. However, there are some facts and trends, reviewed below, that suggest we should be considering alternative strategies that diverge from our present technological trajectory.

The conditions under which the food needed to meet population demands in this 21st century will be produced will surely be different from those that shaped agricultural production in the preceding century. Alterations in these conditions indicate that significant changes will need to be made in the methods employed for food production. The economic and environmental reasons for utilizing what qualify as "agro-ecological" approaches are becoming clearer, reflecting objective realities rather than just ethical or other preferences.

In particular, experience accumulated over the past decade with a production system known as the System of Rice Intensification (SRI), increasingly reinforced by scientific investigations, is pointing to lower-cost opportunities for increasing world food availability, especially for those persons who are most in need. SRI management, applicable also beyond rice, achieves this by making more productive use of available resources. This strategy differs from most of those currently proposed for raising food production, and it makes SRI quite unprecedented, offering some new directions for agricultural technology and policy to explore and elaborate.

The first section below reviews what SRI management can contribute to meeting the challenge of world food production. This leads into a consideration of the factors and trends that are likely to make this century's agricultural systems diverge from the practices, policies, and structures during the previous century. The article then considers briefly the origins of SRI; how it has spread and what it involves in concrete terms; then the scientific controversy and evidence surrounding it; and finally some future implications.[1]

2 Agricultural Trends and Constraints in the 21st Century

Which agricultural technologies prove to be most productive and sustainable over time depends upon institutional relationships and upon the relative availability and productivity of the principal factors of production (Hayami, Ruttan 1985). The combination of still-growing population, at least through to 2050, and continuing declines in arable land, both in quantity and in quality through various causes of soil-system degradation, will by 2050 reduce the food production area available per capita to about *one-third* of what it was in 1950.

Accordingly, the comparative advantage of large-scale, mechanized, *extensive* production can be expected to decline over time. While labor shortages in the agricultural sectors of poorer countries can create incentives for what are called "modern" production methods, the economic logic for *intensification* of production will become stronger over time in terms of relative factors availability and productivity.

This logic will gain strength when energy costs are considered. While petroleum prices cannot be predicted with any certainty even years ahead, let alone for decades, there is no reason to expect energy prices for agriculture in the 21st century to match those in the 20th century. The profitability of farm operations that depend on mechanization and on fertilizer and agrochemical inputs that derive from petroleum materials will be undermined by present and future increases in energy prices. While alternative energy sources can mitigate the financial pressure, there are limits on how far they can substitute for current fossil fuel-based agricultural inputs.

Perhaps trumping all of these influences will be the effects of *climate change*, for which global warming is only one element, and possibly not the most important. Farmers can, within limits, adapt to gradual increases in ambient temperature, by modifying cropping patterns as well as practices. What they cannot readily adapt to are increases in what are euphemistically grouped as "extreme events" – droughts, storms, heat waves, cold snaps. The effects of these will probably be exacerbated by intensified pest and disease problems.

There are also legitimate concerns that continuing our present heavy reliance on applying large amounts of inorganic nitrogen fertilizer will have other adverse impacts on the environment.[2] These and other considerations make "doing more of the same" a less attractive and possibly infeasible option. Future agricultural production is unlikely to be as *extensive* as was evolved during the 20th century. This recasts the question to: *if agriculture becomes more intensified, with what kind of intensification?* The current brand of "intensification" with its heavy reliance on agrochemical inputs is acknowledged by rice scientists as not really sustainable (Cassman, Harwood 1995; Reichardt et al. 1998). There is need, but also opportunity, for a more suitable strategy of sustainable intensification (Royal Society 2009).

3 How is SRI Relevant to "Feeding the World"?

The magnitude of the challenge of meeting world food needs is so great that certainly there will be no single solution or single strategy for achieving this objective. Neither SRI nor the broader phenomenon of agro-ecology can suffice for this purpose by itself. However, evidence from SRI experience over the past decade suggests that making certain changes in crop management can greatly enhance the productivity of available land, labor, water, nutrient, and capital. These changes make it possible to increase food production *with less rather than more cost*. Achieving greater output with reduced inputs is a controversial proposition, to be sure. For the past century, higher output has been achieved with *greater* external inputs, but the impacts of agricultural expansion have had adverse consequences for the world's natural resource base.

The impacts of SRI management have been reviewed in a number of publications[3], so they are just summarized here:

- *Increases in yield* have usually been in the range of 50-100 percent, although they can be lower or even much higher.
- *Water saving* is usually between 25 and 50 percent, as irrigation water is reduced when rice paddies are not kept flooded. SRI rice plants have higher water productivity (Thakur et al. 2010).
- *Costs of production* are usually reduced, even 10–20 percent, because farmers need not purchase different seeds or agrochemicals. This raises farmers' net income by more than their increase in yield.
- *Resistance to pests and disease* is widely reported by farmers, and has been documented by the National IPM Program in Vietnam and by university researchers in India. Also, *biotic stresses* (drought, storms, heat spells, cold snaps) have been found to have less effect on SRI crops, e.g., drought resistance in India in 2009 and 2010. This advantage is likely to become more important as *climate changes* become more pervasive.
- *Higher milling outturn* increases food supply by 10–15 percent, and sometimes more, when SRI paddy rice is milled. More polished rice results from having fewer unfilled grains (less chaff) and fewer broken grains.

It can be difficult to believe all of these impacts from SRI management practices because they sound "too good to be true". But these effects are well documented as the practices described below evoke *more productive phenotypes* from a wide range of rice genotypes, from traditional "unimproved" cultivars as well as from modern varieties and hybrids. It is noteworthy that the principles and practices of SRI are now being adapted to a variety of other field crops such as wheat, sugarcane, millet, maize, and even some legumes and vegetables.

The results so far do not justify a campaign to convert all crop management to SRI or related practices. But they do suggest that food production in the future can be more satisfactory than is anticipated with current purchased input-dependent technologies (Uphoff 2007).

4 SRI as a Civil Society Innovation

The set of irrigated rice production methods known as SRI (originally *Le Système de Riziculture Intensive*) was developed in Madagascar by Henri de Laulanié, S.J., a French priest trained in agriculture who spent half a lifetime working there with poor, smallholding farmers. His empirical insights and experimentation led to an assemblage of practices in the mid-1980s that make the resources used in rice cultivation more productive (Laulanié 1993; Uphoff 2006; Uphoff, Kassam 2009).

While SRI has considerably evolved over the past 25 years, even being extrapolated to use with other crops beyond rice, in its original form SRI mostly involved half a dozen changes in conventional rice cultivation methods. All of these represent generalizable *principles* that are well justified by agronomic science. But in its most concrete form, SRI can be presented in terms of modifications of age-old, common *practices* for anaerobic or flooded rice cultivation around the world.

- When transplanting rice, *use young seedlings* grown in unflooded nurseries with well-drained soil while still at the two to three leaf stage of growth (usually <15 days after seeding); rather than older seedlings, three to four weeks old or more, raised in flooded nurseries with hypoxic soil. The latter have much less growth potential.
- Also when transplanting, *reduce the plant population drastically*, by 80–90 percent, to give plant roots and canopy ample room to express their genetic potential. This is done by planting *single-seedling hills*, rather than three, four or more plants per hill, and arranged in a wider *square pattern*.
- Transplant young seedlings *quickly*, within 30 minutes of uprooting from the nursery; *gently*, avoiding trauma to the plants and especially to their roots; and *shallow*, one to two cm. This will minimize "transplant shock" which sets back the plants' growth.
- Paddy soils should be maintained in *mostly unflooded, aerobic condition* rather than being continuously flooded, as the latter restricts the supply of oxygen to plants' roots. SRI recommends regular but small applications of irrigation water, or alternate wetting and drying.
- When paddies are not kept flooded, weed growth can be more of a problem. To control weeds, but also to *actively aerate the soil*, use of a simple, mechanical hand weeder is recommended.
- Although SRI was initially developed with the use of chemical fertilizers, when these became too expensive for smallholders in Madagascar, it was learned that *compost* or any application of biomass that increases the soil's organic matter (nurturing the soil biota as well as plant roots) can give as good and cheaper, or even better results. While SRI is not necessarily an *organic* production methodology, it reduces or eliminates farmers' reliance on chemical fertilizers.

These methods, when used as recommended with suitable local adjustments (spacing, timing, water management), have enabled farmers in different parts of Madagascar, who had been getting average yields of ~2 tons/ha, to produce two to four times more paddy without use of purchased inputs. What is intensified with SRI is not external inputs, but *knowledge, skill, and management*. During their learning phase, farmers need to make greater labor inputs. But once the techniques were mastered, farmers could reduce these inputs as well as their seed, water, and costs of production (Moser, Barrett 2003; Barrett et al. 2004).

The merits of SRI's alternative methods have gained acceptance only slowly in Madagascar, in part because they visibly contradict (and appear to disrespect) "the ways of the ancestors" which are the foundation of Malagasy culture and religious beliefs. Where there was not enough water control to apply small but reliable amounts of irrigation water, this also impeded the uptake of SRI.

In 1994, the Cornell International Institute for Food, Agriculture and Development (CIIFAD) began working with "Association Tefy Saina", the NGO that Frère Laulanié and Malagasy colleagues established in 1990 to promote SRI. The NGO name did not mean "produce more rice" but "improve the mind/mentality," indicative of SRI's dual objectives, to introduce socio-economic improvements along with resource-conserving agricultural development and food security.

In 1999 and 2000, through CIIFAD efforts, the validity of SRI methods was demonstrated outside Madagascar for the first time, through trials managed by rice scientists at Nanjing Agricultural University in China, and at the Sukamandi rice research institute of the Indonesian Ministry of Agriculture. By 2011, the number of countries where SRI methods have been validated has reached 42. SRI has been shown to work in tropical, subtropical, and temperate environments and across dry, subhumid, and humid moisture climates.

To reach this extent, a great variety of institutions have given support to SRI evaluation and/or expansion at the country level:

- The joint WWF-ICRISAT project on Food, Water and Environment supported systematic evaluations in Andhra Pradesh state of India, 2004–2006; WWF subsequently began funding SRI activity across India.[4]
- The Sir Dorabji Tata Trust (SDTT) in Mumbai has been funding NGO promotion of SRI in poverty-stricken areas of India on a significant scale since 2007.[5]
- Oxfam America has supported SRI extension in Cambodia and Vietnam since 2004 and

2007, and it has since cooperated with WWF and Africare in jointly endorsing SRI.[6]
- Other NGOs have given support in various countries, and a few donor agencies and foundations have given support at country level, through the initiative of individual staff.
- Private sector support has come forth in a number of companies, while in some countries, universities have played the most active role in evaluating and disseminating SRI.
- Government agencies and research institutions have given leadership in Cambodia, China, India, Laos, Nepal, Sri Lanka, and Vietnam; and individuals have played key roles in Bangladesh, Brazil, Costa Rica, Cuba, Gambia, Panama, Peru, and Zambia.

These varied organizations working separately but in effect together, with coordination and communication through CIIFAD, have made SRI an unprecedented *civil society* innovation (Lines, Uphoff 2006). It is different from the more typical agricultural innovations that emanate from the scientific establishment and are transmitted through official extension agencies to farmers needing new opportunities. This could have prompted some of the resistance to SRI.

5 Scientific Evidence in Support of SRI

During the period 1998–2002, a series of theses on SRI was written for the Department of Agronomy at the University of Antananarivo using standard scientific methods which confirmed Tefy Saina's reports on SRI. It was supported by two of the most eminent rice scientists in the world, Prof. Yuan Long-ping in China and Dr. M.S. Swaminathan in India, who showed SRI productivity through their own evaluations. But nevertheless, there were several contradictory articles published in 2004 which dismissed SRI methods as having no general merit (Sheehy et al. 2004), or minimized their importance by asserting that SRI is only "a niche innovation" (Dobermann 2004), or argued that even evaluating SRI would be a waste of resources (Sinclair, Cassman 2004). A subsequent article concluded that SRI is inferior to "best management practices" developed by scientists (McDonald et al. 2006). Despite rebuttals of the data and analysis presented in these critical articles (Stoop, Kassam 2005; Uphoff et al. 2008), these critiques and other objections succeeded in making SRI "controversial", so that during the past decade, foundations and donor agencies have generally refrained from giving support for the evaluation of SRI methods in a more systematic way than NGOs and SRI practitioners could undertake without funding and research expertise. Thus far, only Jim Carrey's "Better U Foundation" has provided support for trans-national work on SRI, also funding SRI dissemination in Madagascar, Mali, and Haiti.

Even without financial backing, however, a number of scientific studies have begun appearing in the literature, e.g., Lin et al. (2009), Mishra and Salokhe (2008), Thakur et al. (2010), Uphoff et al. (2009), and Zhao et al. (2009). Evaluations from countries as varied as the Gambia (Ceesay et al. 2007), Indonesia (Sato, Uphoff 2007), and Myanmar (Kabir, Uphoff 2007) have provided information on the empirical foundations of SRI performance.

In March 2011, the journal *Paddy and Water Environment* published a special issue on SRI (Vol. 9, No. 1). This contained half a dozen scientific articles plus nine country reports from Afghanistan via Iraq to Mali to Panama that brought together a strong evidential base supporting the previous claims and reports on SRI productivity. Quite possibly, attention will now focus on a better understanding of the agro-ecological mechanisms that produce SRI results – particularly the larger and longer-lived root systems and the more abundant and diverse soil biota that support higher crop productivity. There should no longer be much doubt about the potential payoff from getting a better understanding of the mechanisms, limitations, and optimization of SRI methods. Explaining and exploiting this potential and addressing sustainability questions is important and remains to be done systematically.

6 Future Prospects for SRI

The productive possibilities that SRI experience and understanding are opening up will not by themselves meet the challenge of feeding the world. But there is enough evidence now to support expanding our investigation and dissemination of the principles and practices that constitute SRI, especially as extrapolated to other crops beyond rice. SRI represents a paradigm shift for the agricultural sector: from an external input-dependent approach, revolving around genetic improvements or modifications, to more of an ecological perspective and strategy.

In a way, SRI amounts to a "re-biologization" of agriculture, which has during the past hundred years been made a more industrial, engineered undertaking. Within both frameworks, the critical relationships are between inputs and outputs. But in an industrial operation, there are always proportional relations between the two sets of factors. From an industrial perspective, plants are like carbon-based machines, to be designed and re-designed to meet our purposes.

Understood in ecological terms, plants are organisms with their own capacities, strategies, repertoires, etc., that are activated in response to environmental conditions. Plants do not exist and survive separately from their surroundings, but rather they are thoroughly interpenetrated by – and for the most part benefited by – microorganisms, much as humans and other animal depend on their respective microbiomes. Instead of regarding soil mostly in terms of its inert mineral elements, this alternative perspective appreciates the potentials, limitations, and dynamics of *soil systems* as a living component of agro-ecosystems (Uphoff et al. 2006). Whereas most soil science focuses on soil chemistry and soil physics, with only a minority of research focused on soil biology, the latter should be the crux of soil analysis if realistic knowledge is sought. Much contemporary soil science is based on studies of soil samples that have had the life in them destroyed by fumigation or sterilization, so that our generalizations and conclusions are based on cadaverous soil, not on functioning soil systems.

When the life in the soil is husbanded, parallel to a crop husbandry that regards plants as organisms rather than as machines, we see some spectacular productivity results possible, in rice, wheat, sugarcane, and many other crops. We do not know how far the experiences with SRI and related methods can be taken; but there is reason to think that with good evaluation and further evolution of the methods and insights, some major advances can be made beyond what has been achieved so far.

Who would have thought that soil rhizobia migrating from the root zone up through the roots and stems into rice plant leaves would, by themselves and under controlled conditions, be able to increase plants' levels of chlorophyll, rates of photosynthesis, and ultimate grain yield? (Chi et al. 2005) Or that "infecting" rice seeds with a fungus (*Fusarium culmorum*) could induce greater root growth and earlier emergence of root hairs that help seedlings grow more vigorously? (Rodriguez et al. 2009) There is still much to be discovered and evaluated. But this will not happen without moving beyond genocentric, input-focused agricultural strategies.

We must be careful not to let the successes to date create unrealizable expectations; but neither should the divergence of SRI practices and results from present thinking and achievements justify resistance to innovation, based on *a priori* reasoning or vested interests that benefit from the status quo. The challenges of the next several decades are too immense and ominous for "business as usual" to offer any sustainable comfort.

Notes

1) There is not enough space for a full discussion of all these issues, but more information is available at: http://sri.ciifad.cornell.edu.
2) The former chief executive of the UK's Natural Environmental Research Council, John Lawton, has characterized the rising use of N fertilizer as "the third major threat to our planet, after biodiversity loss and climate change" (Nature, 24 February 2005), referring to the impacts of reactive nitrogen on water quality and aquatic ecosystems.
3) See Uphoff and Kassam 2009; Africare/Oxfam America/WWF-ICRISAT Project 2010; Kassam, Uphoff and Stoop 2011.
4) See http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_resources/?uNewsID=114460.
5) See http://www.dorabjitatatrust.org/about/pdf/09-10/Annual_Report_2009-2010.pdf.
6) See http://www.sri-india.net/documents/More_Water_For_The_Planet.pdf.

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Bridging Nutrition and Agriculture

Local Food-livelihood Systems and Food Governance Integrating a Gender Perspective

by Stefanie Lemke and Anne C. Bellows, University of Hohenheim, Stuttgart[1]

Worldwide hunger is still increasing and there is an urgent need to address the structural causes of hunger and food insecurity, including gender discrimination and power imbalances. We review the shortcomings of the separated food security and nutrition security approaches, arguing that they need to be united in the context of local food systems and governance. Current measures to address malnutrition and hunger are favoring paternalistic approaches that perpetuate aid, neediness and dependency. We suggest alternative frames that integrate food and nutrition security in a food systems and rights-based approach, namely through sustainable livelihoods and agro-ecology, and including a gender perspective that so far has been missing. We argue that this will ultimately be more cost-effective and sustainable, building capacity and autonomy of local food systems through local governance approaches that foreground inclusive participation of all members of society.

1 Introduction

The 6th Report on the World Nutrition Situation by the "United Nations System Standing Committee on Nutrition" (UNSCN 2010) highlights the crucial role of the agricultural sector to address food and nutrition problems, emphasizing that nutrition-friendly, sustainable agricultural development is key to improving food and nutrition security. Investments in small-holder agriculture, especially if targeted at women, can be important means of increasing both farm and rural non-farm household incomes. Besides higher agricultural productivity this refers for example to additional impacts such as increased demand by farmers for labor and locally produced goods and services, and lower commodity prices through a fall in staple food prices, with many rural households being net food buyers (Godfray et al. 2010;