A DECADE'S PERSPECTIVE ON THE USE AND SPREAD OF THE SYSTEM OF RICE INTENSIFICATION (SRI)

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INTRODUCTION

This paper considers the System of Rice Intensification (SRI) from my perspective of more than a decade of involvement with this unprecedented innovation. Despite repeated insistences that 'SRI is not a technology,' not a tool or technique or new variety, it is still too often viewed in this limiting, misleading way. SRI is better understood as a ***methodology*** rather than as a technology; however, it is also more than a methodology. It can be considered, variously, as ***a phenomenon***, ***a philosophy***, ***a paradigm shift***, ***a social movement***. SRI is all of these, although it remains grounded in very concrete, specific, and verifiable ***biophysical relationships***.

The specific practices that are associated with SRI focus on changing and improving the environment for rice and other plants above and (especially) below ground. The more favorable growing conditions created by SRI practices are explainable and justified by well-established agronomic principles, which evoke more vigorous, more productive, more resilient ***phenotypes*** (plants) from available crop ***genotypes*** (varieties). There is nothing magical or mysterious about SRI; it represents good agronomy.

Some critics have compared and opposed SRI with '*best management practices*' (McDonald et al. 2006). This is as mistaken as the contrary contention that 'SRI is *just BMP*' and nothing more. This implies that SRI provides no new insights and opens up no new opportunities. SRI experiences and analyses have, in fact, demonstrated that modifying conventional management of plants, soil, water and nutrients can lead to larger, deeper, longer-lived ***root systems*** and more abundant, diverse and active ***soil biota*** (e.g., Lin et al. 2009; Mishra and Salokhe 2008, 2010; Thakur et al. 2010a, 2010b; Uphoff et al. 2009; Zhao et al., 2009, 2010). In turn, more profuse root systems and soil biota can have strong positive impacts on plants' productivity and vigor.

Plant roots and soil biota have, unfortunately, been mostly ignored in the agricultural R&D strategies favored in recent decades, which have focused on making genetic improvements and increased use of external /purchased inputs. SRI is not just an opportunistic compilation of improved practices as has been suggested.[1] SRI's theoretical foundations have been inductively derived from field observations followed by experimental evaluations. Its emergence has thus been driven more by experience and empiricism than by prior assumptions and available literature. It is a civil society innovation that has advanced with the involvement and support of agricultural scientists who are willing to work with and learn from farmers, and who think outside of their respective disciplines' standard mental 'boxes.'

Why SRI is a Work in Progress, not a Fixed Technology

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[1] One IRRI senior researcher wrote to me in an e-mail earlier this year: 'The way I see SRI is as a movement that adopts anything that improves productivity and profitability, and labels it SRI. … when people ask me whether IRRI works on SRI, I can safely respond 'yes, we have been doing that for 50 years!' The only difference is that we use different terms such as Integrated Crop Management (ICM), Best Management Practices (BMP), and Good Agricultural Practices (GAP). In the end, it is all about site-specific adaptation and optimization. Greetings, . . ." While SRI does entail both *adaptation and optimization*, it has much more substance and theory than is acknowledged in this dismissal of its distinctiveness.

Perhaps the best evidence that SRI is 'not a technology' in the Green Revolution tradition would be the following three observations, which show how the original or 'classic' SRI has been evolving:

- 'SRI' no longer applies just to ***rice***, since its concepts and methods are being adapted and extrapolated to ***other crops***, such as wheat, ragi, sugar cane, even legumes and vegetables.
- What started as a system for ***irrigated rice production*** has now been extended successfully to the production of ***upland, rainfed rice*** in a number of countries, including India.
- While SRI was initially *labor-intensive* and intended primarily for *smallholders*, its principles are being applied now in ***larger-scale operations*** and with various degrees of ***mechanization***. For many farmers, SRI is now *labor-saving*, and further mechanization will make this benefit more widespread.[2]

Why SRI Should No Longer Be Regarded as Controversial

Governments in India, China, Indonesia, Vietnam and Cambodia – *where two-thirds of the world's rice is currently grown* – have begun to promote SRI methods through their extension services and working with NGOs and universities disseminating SRI knowledge. This emerging consensus in major rice-growing areas should settle the 'debate' about SRI. Experience in these countries is summarized in a later section, after addressing the question of what should be regarded as 'SRI' or 'not SRI.'

It should be clear that an early 'rush to judgment' and several attempts to dismiss SRI were premature, not based on the kind of systematic empirical work on which scientific progress depends (e.g., Dobermann 2004; Sheehy et al. 2004; Sinclair 2004; Sinclair and Cassman 2004). Unfortunately, skeptics declined to work with those who had the most knowledge and understanding of SRI, including farmers, instead relying on their own *a priori* reasoning and questionable modeling (Stoop and Kassam 2005).

There is now extensive evidence in the peer-reviewed international literature, some cited in the Introduction above, so SRI should not be considered as 'controversial.' It is well-documented that SRI practices, appropriately combined and adjusted for local conditions (farmers' adaptation of SRI practices is part of its methodology), can produce more productive phenotypes. To be sure, improved management is not a substitute for having and using the best available genotypes. Continued efforts to improve genetic potential are justified. All of the best SRI results so far have come from high-yielding varieties or hybrids. However, ***genetic improvement is not a precondition*** for farmers to improve their productivity and security. Improvements as great, and sometimes even greater, can be achieved by ***better management practices***. Plant breeders should not feel threatened by SRI achievements, but should be prepared to give credit to management innovations where credit is due.[3]

I. WHAT IS SRI?

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[2] In Madagascar SRI was initially reported to be labor-intensive (Moser and Barrett 2003). However, even there it is seen that the methods become ***labor-saving*** once farmers gain experience, skill and confidence with the new methods (Barrett et al. 2004). A personal observation: After learning – as early as 2002 from Sri Lankan farmers – that SRI can reduce labor requirements, in addition to enabling farmers to save seeds and water and lower their production costs, it became obvious that SRI would eventually succeed on a large scale in many countries.

[3] Much of the yield improvement achieved on-station by the '*new plant type*' (NPT) -- heralded by IRRI scientists in the 1990s as raising yield potential by up to 25% -- should have been ascribed to the management practices used: 14-day seedlings, planted singly, with square spacing of 25x25 cm (Khush 1996), all SRI practices. NPT plants continued to be grown under flooding, however, with heavy applications of chemical fertilizer and with herbicides used instead of soil-aerating mechanical weeding. Despite large investments in its development, the NPT remains largely 'on the shelf,' not being superior to available inbred varieties (Peng et al. 2004). It may have been overlooked that when rice plants are bred to have *fewer tillers per plant*, the NPT breeding strategy, they will also have *fewer roots*. Their greater 'sink' capacity is constrained by limited 'source' capacity (Kobata and Iida 2004).

Just as SRI is not a technology, it is **not a thing.** SRI is not a variety, or a material input, or a tool. Such material things are easier to measure and to evaluate than is something like SRI which is also **mental.** SRI is actually ***many things***, based on certain *ideas*, explainable in terms of basic *principles*, that lead to modified *practices*, adapted to local *conditions*. This is confusing for persons who think in ***reductionist*** terms, who want SRI to be 'only this and nothing more,' or who want SRI to be 'always that' and not subject to change and evolution. This confusion should remain their problem more than ours.

A growing number of scientists, policy-makers, businessmen, teachers and others understand and appreciate ***the evolving and diffuse nature of SRI***. The core concepts and principles of SRI are reasonably definable while the 'boundaries' of SRI are more ambiguous. Probably more than 2 million farmers worldwide have come to appreciate how to make the land, labor, capital and water that they use for growing rice more productive by modifying their cultivation methods, learning from the three decades of work in Madagascar by Fr. Henri de Laulanié, the originator of SRI. Farmers seem to have less difficulty in comprehending 'what is SRI?' than do more-educated persons, whose learning makes it difficult for them to 'think outside the box' because they are so confident in their formal knowledge.

SRI in Operational Terms

The following discussion attempts to provide an analytical account of what are the ***minimum characteristics*** of rice production, of what would qualify this as meeting the basic requirements for SRI.

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A. <u>Water</u>: If farmers have previously flooded/irrigated their rice crop (this qualification takes account of the fact that there are now upland, rainfed versions of SRI), then SRI management means **REDUCTION IN WATER APPLICATIONS**, either through small/smaller daily applications of water or through alternative wetting and drying (AWD), **MAINTAINING PADDY SOIL IN MOSTLY OR INTERMITTENTLY AEROBIC CONDITIONS** at least during the vegetative growth stage. SRI farmers should be moving toward applying '*a minimum of water*,' to use Fr. de Laulanie's phrase, as this promotes the health and growth of roots and also supports the abundance and diversity of aerobic soil organisms.

How much less water? When or how often should water be applied? These are matters to be worked out according to soil conditions, climate, and time/labor constraints. **<u>SRI means less water use</u>**. Where farmers have no control over their water supply, they should be taking steps to ensure that the roots of their rice plants ***do not suffocate and degrade because of standing water.*** Under rainfed conditions, as with irrigated production, SRI farmers are trying to **<u>grow roots</u>** so that their rice plants can utilize water available in lower soil horizons. Thus, a first requirement for SRI is ***modified water management***.

B. <u>Plant Populations</u>: SRI greatly **REDUCES THE NUMBER OF PLANTS** per m^2 or per hectare, by at least two-thirds and even by 80 to 90%. With SRI management, one plants **SINGLE SEEDLINGS per hill**, or at most two seedlings. In low-fertility soil, two seedlings will give higher yield than single seedlings. However, in soil with average fertility and certainly with high fertility, single seedlings if young and unflooded will outperform clumps of seedlings, because of greater root and canopy growth.

SRI consequently means **WIDER SPACING between hills**, preferably in a **<u>square pattern</u>** to expose the plants maximally to the sun and air. Some SRI variations include **rectangular planting** or some other geometric shape. One variation is **triangular planting** developed in Sichuan province of China (Yuan 2002). This pattern reduces the number of hill per m^2 by half, putting three plants in each hill, with 7-10 cm spacing between the three plants placed in a triangular pattern. This kind of wider spacing contributes to greater growth of both roots and canopies. It implements the principle of 'wider spacing' with *a plant population 50% higher* than in 'classic' SRI. This demonstrates how SRI can evolve and diversify in accord with its basic principles. Exact spacing and number of plants per hill should vary to optimize resulting grain production. The superiority of single seedlings over clumps of rice plants has been explained with standard research methods evaluating conventional practice (San-oh et al. 2006).

C. <u>Age of Seedlings</u>: If the crop is established by transplanting (there *direct-seeding* variants of SRI, but transplanting is still the main method for crop establishment), **SRI MEANS YOUNGER SEEDLINGS**, still at their 2-3 leaf stage, before the start of their 4^{th} phyllochron of growth. This means preferably 8-12 days old, and not more than 15 days of age as a rule. Transplanting beyond this age compromises the growth potential of roots and canopy. In some circumstances such as cold temperature, 'young seedlings' can be as old as 20 days, since age is reckoned by biological processes rather than by the calendar.

D. <u>Organic Matter</u>: To improve the structure and functioning of paddy soils and to enhance the populations of soil biota, **INCREASING ORGANIC SOIL MATTER** can be considered as a fourth defining characteristic of SRI. It makes sense to expect that SRI practice will include **some increase in organic fertilization**, but this need not completely replace chemical fertilizers, unless a farmer intends to practice 'Organic SRI.'

Organic fertilization is not a necessary feature of SRI, according to Fr. Laulanié, who developed SRI during the 1980s using chemical fertilizer. Rather, organic matter is an 'enhancement' of SRI benefits. In the late 1980s when fertilizer subsidies in Madagascar were halted and the price of fertilizer escalated, Laulanié and the farmers working with him started using ***compost*** instead of fertilizer, and their crop results were even better. Using organic fertilization is a necessary qualification for 'organic SRI,' which is a special kind of SRI, for which chemical herbicides or insecticides are not used either. But it does not distinguish 'SRI' from 'not SRI.'

Some evaluations have suggested that a ***combination*** of organic and inorganic fertilization together with the other SRI practices can give the highest yields. This could reflect the dynamic of optimization. However, there is not yet enough evidence to draw firm conclusions or make recommendations on this. Many factors such as soil type, preexisting soil fertility levels, and abundance and diversity of soil organisms will affect what is the optimum application of organic and/or inorganic materials in any case.

Our SRI colleague Shuichi Sato in his work on SRI in Indonesia has distinguished between

- **'Basic SRI'** which is most or all of the other SRI practices together with a 50% reduction in chemical fertilizer and with an increase of organic fertilization, and
- **'Organic SRI'** with no synthetic fertilizer or crop protection (Sato and Uphoff 2007).

Sato-san has promoted the latter personally, setting up an NGO to promote 'organic SRI' at the same time that the Japanese-funded project which he advised promoted the former. Both versions can coexist, however, with farmers deciding how best they can apply and benefit from SRI principles.

A Minimal Characterization of SRI

These considerations justify the following 'reductionist' criteria for what qualifies as 'SRI.' Vietnamese colleagues would probably refer to this formulation as '***the three lesses and the one more.'***

A. **Reduced water application**, to obtain mostly aerobic soil conditions during the plants' growth phase, and to have more aerobic conditions during the reproductive phase as well.
B. **Reduced plant density**, with plants preferably planted singly and in a square pattern for root and canopy growth.
C. **Reduced age of seedlings** -- if transplanting is done -- preferably 8-12 days old (at 2-3 leaf stage) to enhance both tillering and root growth, and

D. **Increased application of organic matter** to the soil to support more root growth and soil biota, through better structuring and functioning of the soil.

To these four **criteria** should be added four important **recommendations** to enhance crop performance:

1. SRI should begin with **CAREFUL SEED AND SEEDLING SELECTION**, so that farmers are using the most promising and healthiest planting material possible. Large, well-filled seeds should be used in the nursery, and only the best seedlings should be transplanted, for most productive plants.
2. **NURSERIES SHOULD NOT BE SUBMERGED** because seedling roots need oxygenation like any other living things. Rice seedlings can survive when under water, but they will not be as healthy as plants that start their growth in well-aerated soil (Mishra and Salokhe 2008).
3. SRI plants benefit from **TRANSPLANTING QUICKLY, CAREFULLY AND SHALLOW**, so that there is ***little or no transplant shock***. Various kinds of direct-seeding or mechanical transplanting are being developed, trading off some yield for the sake of labor saving. Transplanting is not a required feature of SRI; but if this is done, seedlings should be young and carefully handled.
4. SRI practice benefits also from **ACTIVE SOIL AERATION** using a ***mechanical weeder*** that controls weeds as it enhances root and plant growth. While this practice is not necessary for getting benefit from the other practices, farmers have found that it can raise their yields by 1-3 t/ha. While active soil aeration is a *key factor* in getting best SRI results, I would not include it as a necessary *criterion* for whether or not certain rice cultivation can be considered as 'SRI.'

These four recommendations are not restricted to SRI; they are beneficial whether or not other SRI practices are used. Moreover, they are not as ***counterintuitive*** as are the first four practices listed, the minimum *criteria* for SRI. Stated in one sentence, the core conception and implementation of SRI is a realization that **farmers can get more robust plants** and **higher yield** from: (i) ***less water***, (ii) ***less seed***, (iii) ***younger seedlings,*** and (iv) ***giving up or reducing chemical fertilizer***. Seed selection, unflooded nurseries, careful transplanting, and soil-aerating weeding are all recommended as beneficial enhancements.

SRI in Strategic Perspective

These practices together and respectively can contribute to rice plants that have deeper, longer-lived **ROOT SYSTEMS** and to more abundant and diverse **SOIL BIOTA**, which provide many services and benefits to plants. The resulting plants will also be ***more resistant to pests and diseases***, and to ***drought, storm damage, cold snaps,*** etc. There is also some evidence that growing rice crops in this way will contribute to ***net reductions in greenhouse gases*** (GHGs), but more research is needed on the latter issue before strong claims can be made. SRI paddy will produce 10-15% ***higher outturn of milled rice*** because of fewer unfilled grains (less chaff) and less breakage of grains during the milling process.

SRI has grown and prospered as a force within the agricultural sector ***because it has not been treated in a reductionist manner***. We have not said: 'SRI is **only** this,' or 'SRI is **always** this,' or 'SRI is **nothing more than** ….' Reductionist ways of thinking and speaking are counterproductive in many areas of our lives, but they are ***particularly antithetical for SRI***, which keeps growing and evolving because it has not been mentally encapsulated. If SRI had been conceptualized and communicated in a reductionist manner from the start, it would probably have been stillborn -- rather than becoming the vigorous, robust phenomenon that it is today with, we think, still unexploited potential to be developed.

II. COUNTRY EXPERIENCES

As suggested above, the objections to SRI voiced by some rice scientists become less tenable with each passing season, and with each country added to the list of those where SRI methods have proved capable of producing more productive phenotypes from given rice genotypes. This paper focuses on the main rice-producing countries, where two-thirds of the world's rice is produced, with then a quick review of SRI around the world. We start with India.

A. India: This workshop will look at SRI experience in this country, with more detailed and extensive information than is available at our SRI support center at Cornell University. SRI has come a long way from the first trials in 2000 at Tamil Nadu Agricultural University led by Dr. T. M. Thiyagarajan in cooperation with a multi-country project on water-saving rice production led by Wageningen University, with which I was associated as an advisor. There were about the same time some trials and demonstrations of SRI initiated by organic farmers and NGOs in Tamil Nadu, so the genesis of SRI in India has both formal institutional and non-formal, grassroots origins (Shambu Prasad 2006).

- Both the **Directorate of Rice Research** of ICAR in Hyderabad (Kumar et al. 2007) and the **Directorate of Rice Development** in Patna have been working with SRI methods for some years.
- The **National Food Security Mission** of the Government of India has made SRI promotion part of its campaign to raise food production and incomes in poverty-targeted districts in 12 states.
- The **Sir Dorabji Tata Trust** has assisted dozens of NGOs in introducing SRI methods to at least 65,000 poor households across 12 states of eastern and northern India. According to an evaluation done in March, 2010, 25,000 of these are also using SRI methods for other crops.
- dThe **National Bank for Agricultural and Rural Development** (NABARD) has been expanding its lending program in 14 states to self-help and other local groups to take advantage of SRI's productivity opportunities.
- **State Governments** in Tamil Nadu, Tripura, Orissa and Andhra Pradesh through their extension services, often in collaboration with state agricultural universities, civil society organizations and panchayati raj institutions, have extended SRI practices to perhaps over 500,000 households.
- **NGOs** including PRADAN, People's Science Institute, WASSAN, AME and several hundred other NGOs have launched a varieties of SRI programs, with backing from several financial sources. These programs may have reached more than 100,000 households already.
- **University faculty** in Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Jammu, Karnataka and other states have become involved in SRI promotion in many parts of India, generating knowledge at the same time that they can benefit rural people directly.

This workshop should provide or produce more information on all of these efforts across India.

B. China: Four early initiatives here to evaluate the SRI concepts and practices learned from Madagascar preceded or were roughly concurrent with initial engagement with SRI in India:

- **Nanjing Agricultural University** scientists conducted trials in 1999 that validated SRI methods. Their yields of 9.2-10.5 t/ha made China the first country outside Madagascar to start utilizing SRI (Wang et al. 2002). Such yields could be obtained with hybrids and high fertilizer inputs, but they could not be reached with a 50% reduction in water use -- so this made SRI of interest.
- The **China National Hybrid Rice Research and Development Center** under its director Prof. Yuan Long-ping, known as 'the father of hybrid rice,' undertook trials in 2000. These showed SRI methods adding 1-3 t/ha to the already high yields of hybrid rice (Yuan 2002). In April, 2002, Yuan hosted the first international meeting on SRI, which had participants from 15 countries plus 60 Chinese rice scientists (http://sri.ciifad.cornell.edu/proc1/index.html).
- The **China National Rice Research Institute** began its evaluations of SRI methods in 2001. Based on its evaluations of SRI (Tao 2002; Zhu 2002), it joined in co-sponsoring the 2002 international meeting, with its Director-General, Dr. S. H Cheng, and other CNRRI staff participating.

- At the suggestion of Prof. Yuan, the **Sichuan Academy of Agricultural Sciences** and some other institutions in Sichuan Province began evaluating SRI methods in 2001 (Zheng et al. 2004).

By 2004, there was enough evidence of SRI merit that the **China Academy of Agricultural Sciences**, under its president Dr. Zhai Huqu, recommended SRI for use in improving rice productivity. In China, implementation of agriculture production is left to the provinces so not central program was initiated.

The **Sichuan** Provincial Department of Agriculture (PDA) began promoting SRI in 2004, with 1,120 ha under SRI management; by 2008, a total of 650,000 ha had been cultivated under SRI management. Average SRI yields over the period 2004-2008 were 9.2 t/ha, 1.63 t/ha over the already high production level in Sichuan. Sichuan farmers with SRI produced **an extra 1.04 million tons of paddy,** with less water and lower costs of production. According to the PDA, SRI methods were used on 285,867 ha in 2009.

The other province where SRI has been seriously promoted is **Zhejiang**, where CNRRI is located and where CNRRI scientists have assisted the PDA in SRI extension. The Zhejiang PDA reports that from 2005 to 2009 there were 688,000 ha of rice area under SRI management. With SRI methods there was an average yield increase of 1.253 t/ha, **adding 862,000 tons of paddy** to provincial production, with reduced water and input requirements. With such results, SRI utilization will surely spread in China.

In China, however, the current national strategy for rice development favors the breeding and promotion of hybrid varieties, with less interest in management innovations. Also, there are few NGOs in China comparable to those in India; and Chinese universities are not as involved with extension as in India. Thus, India has more institutional potentials for taking more advantage of SRI opportunities compared to China. A decade from now, it will be interesting to assess which country has made the most use of SRI productivity options, and why.

C. Indonesia: This was the second country where SRI methods were validated outside of Madagascar, with positive results already in the 1999-2000 wet season. By 2002, after trials across eight provinces, the Ministry of Agriculture's **Agency for Agricultural Research and Development** included SRI practices in its Integrated Crop/Resource Management (ICM) strategy for rice improvement (Gani et al. 2002). However, the Ministry did not begin investing in SRI promotion until its **Directorate of Land and Water Resource Management** began funding of organic SRI training in 55 districts across 15 provinces in 2007.

The **National IPM Program** in Indonesia started trials in West Java in 2001, assessed and promoted through Farmer Field Schools (http://sri.ciifad.cornell.edu/countries/indonesia/indocmis01.pdf). In 2002, trials started in Eastern Indonesia under an irrigation management project under the **Public Works Department** (PU), with Japanese funding and technical assistance from the consulting firm Nippon Koei. Over the next nine seasons, the TA team supervised on-farm comparison trials (N=12,133) across eight provinces, with an average yield increase of 78%, reducing water use by 40%, and chemical fertilizer by 50% (Sato and Uphoff 2007).

Various **NGOs** have promoted SRI in different parts of this large country, such as ADRA, VECO, and World Education. **Caritas** introduced SRI in Aceh after the December 2004 *tsunami* disaster. There, farmers who had previously gotten average yields of 2 tons/ha have been able to average 8.5 ton yields with SRI methods (http://www.caritas-europa.org/module/FileLib/RiceaplentyinAceh.pdf). Several **universities** have also become involved with SRI evaluation, particularly IPB and Andalas. In 2008, an **Indonesian Association for SRI (INA-SRI)** was formed with members from a great variety of institutions.

There has been a particular interest in **organic SRI** in Indonesia, building on the National IPM Program's early experience. An NGO, **Aliksa Organic SRI Consultants**, was formed, with an organic SRI training center at Nagrak in West Java (http://www.indonesiaorganic.com/detail.php?id=289&cat=31). The **Nagrak Organic SRI Centre** (NOSC) has conducted training for Indonesian, Malaysian and Timor Leste technicians and farmers as well as arranging training for technicians and farmers in the Solomon Islands. With four training centers across Indonesia now, and given the regional scope of its activities, NOSC is considering changing its name to *Nusantara Organic SRI Center*. 'Nusantara' means 'archipelago' in Bahasa Indonesia and thus can refer to the whole insular Southeast Asian region.

The large Indonesian foundation **MEDCO** has given support to organic SRI through several organizations and universities (http://www.medcofoundation.org/sprog.php?id=21&strlang=eng). It also has brought SRI to the attention of Indonesia's President, Dr. S.B. Yudhoyono, who presided at an Organic SRI Harvest Festival in Cianjur in July 2007. With over 300 farmers in an audience of 1,200 Indonesians, the President stated, among other things:

> "… this SRI method is a proven example where agriculture can be sustainable, and it is a correction to the Green Revolution… This SRI method, by being a solution instead of adding to the problems [of environmental deterioration], and by providing opportunities for agricultural development, is therefore very suitable for Indonesia."
> (http://ciifad.cornell.edu/sri/countries/indonesia/indopresident073007.pdf)

Even with top-level support, spreading SRI use in Indonesia has been challenging, however, because the far-flung archipelago country is so diverse. A great variety of organizations are promoting SRI, ranging from the **Rotary International Club** in Ubud, Bali (http://www.rotarybaliubudsunset.org/training-farmers-to-increase-rice-yields/), to the giant tobacco-products company **Sampoerna PT**, which as a corporate social responsibility initiative has established an extension program for SRI in East Java. It has cooperated in research and produced an excellent manual on SRI practice (http://www.pdf-searcher.com/SRI-Manual-made-by-Sampoerna-in-Indonesia-(Bahasa-Indonesia).html).

The number of SRI users in Indonesia does not match India or China, but there is a diversified institutional support network across the country, and with **INA-SRI** providing connectivity to the various efforts, further spread could be rapid. The variety and vitality of SRI efforts in this country are seen from its web page: http://sri.ciifad.cornell.edu/countries/indonesia/index.html

D. Vietnam: SRI evaluation and use started several years later here than in the other countries, but Vietnam has become a leader in SRI extension since learning about SRI methods from the National IPM Program in Indonesia in 2003. The **National IPM Program** in Vietnam began a systematic evaluation, and by 2006 it had results from **3,450 farmers** across 17 provinces. These showed a yield increase less than in most other countries, of only 9-15% (possibly because of different soil biota than elsewhere). But this was achieved with 70-90% less seed, one-third less water, a 20-25% reduction in nitrogen fertilizer, and greater pest and disease resistance which cut the need for agrochemical protection. With lowered costs of production (by 2-3 cents/kg), farmers' net income went up about $125/hectare. These figures are from an April 2007 report by the National IPM Program. Such results led the **Ministry of Agriculture and Rural Development** (MARD) to designate SRI officially as a 'technical advance' in October 2007.

Oxfam America began working with the National IPM Program in 2006 to assist in the spread of SRI, particularly in poorer and hilly regions, and to facilitate multi-institutional collaboration for utilizing SRI opportunities. Faculty at **Thai Nguyen University** and **Hanoi Agricultural University** had already begun to evaluate and spread SRI use a year or two earlier, through their external contacts (respectively, with

Chiangmai University in Thailand and the NGO International Development Enterprises, IDE). Faculty at these institutions joined in the collaboration, as did the NGO **Center for Sustainable Rural Development** (SRD), which now maintains an SRI Vietnam website (http://vietnamsri.wordpress.com/) with Oxfam America assistance. The **Japanese Volunteer Corps** (JVC) also participates in the Vietnam SRI consortium, as its volunteers are working with SRI there as in Cambodia and Laos. MARD's Plant Protection Department reports that SRI use in Vietnam in 2010 was **over 800,000 farmers**, 20% of them using 'full SRI,' i.e., all of the recommended practices, and 80% 'partial SRI,' not yet doing the full set. This represents about a 200-fold increase in four years. That most SRI farmers are not yet using all of the methods means that there is still considerable scope for further gains in productivity and profitability.

E. Cambodia: This was one of the first countries to begin SRI utilization, primarily through the initiative of an NGO known as **CEDAC**, the Center for Studies and Development of Cambodian Agriculture. It was established in 1997 with assistance from the French NGO GRET. After the director of CEDAC, Dr. Y. S. Koma, tried out the methods himself in 1999, after reading about them in the *LEISA Newsletter*, he got 28 farmers to use SRI practices in 2000. This number expanded to 400 the next year, and 2,000 in 2002. In 2006, with assistance from **Oxfam America** and the German donor agency **GTZ**, the **Ministry of Agriculture, Forestry and Fisheries** (MAFF) established an **SRI Secretariat**, managed jointly with CEDAC.

The number of Cambodian farmers using SRI methods in 2009 was reported by the SRI Secretariat to be 110,000 on 60,000 ha. Average SRI yield, 3.48 t/ha, is about 1 t/ha more than with usual production methods; note that about 80% of SRI in Cambodia is grown under rainfed conditions with no irrigation. The Minister of Agriculture has been giving personal leadership for SRI adoption (http://sri.ciifad.cornell.edu/countries/cambodia/CamMinisterChanSarun082109.pdf); CEDAC reports that Premier Hun Sen, when he addresses groups of farmers, gives his own endorsement of SRI use.

F. Other Countries: As 90% of the world's rice is produced (and consumed) in Asia, this region has been the main focus of SRI efforts so far. Discussing all the other countries where the effectiveness of SRI methods has been demonstrated to give farmers more productive phenotypes (plants) from the genotypes (varieties) that they presently use would make this more an encyclopedia than a paper. So I will quickly review SRI results and situation on a regional basis.

1. East Asia and Pacific: There has been little interest in SRI in **Japan** at the policy level because of that country's surplus production situation, but research done for Tokyo University of Agriculture and Technology has shown, for example, that SRI methods (younger seedlings, wider spacing, and no flooding) makes rice plants ***more resistant to lodging*** under the stress of rain and wind (Chapagain and Yamaji, 2009). A thesis done at Gyeongsang Agricultural University in the **Republic of Korea** has shown SRI effects with green manures and cover crops, but there has been no expansion as far as we know.

In the **Democratic People's Republic of Korea**, cooperatives near Pyongyang, with cooperation from the American Friends (Quaker) Service Committee, have tried SRI methods, adding 0.5-1.0 t/ha to yield, with 250 ha under such management in 2009. The **Solomon Islands** government made SRI the cornerstone of its National Rice Policy in a Cabinet white paper January 2010, after Norman Uphoff visited the country the previous November. It invited a farmer from East Java, Indonesia, Ms. Miyatty Jannah, to visit Solomon Islands in October to provide training to farmers and extension personnel there. She has been invited to return for a whole season of training in 2011 in SRI's first extension into the Pacific Islands.

2. Southeast Asia: Other Southeast Asian countries where SRI has gotten started besides Indonesia, Vietnam and Cambodia are the **Philippines**, **Thailand**, **Laos**, **Myanmar**, **Malaysia** (including Sabah), and

Timor Leste. Each has a different and interesting story. Since three SEA countries have been discussed above, anyone interested in knowing more about SRI in this part of Asia should consult the respective country pages on the SRI website: http://sri.ciifad.cornell.edu/countries/index.html

3. South Asia: Similarly, SRI has been spreading in other countries in this region, **Bangladesh**, **Bhutan**, **Nepal**, **Pakistan**, and **Sri Lanka**, although not as rapidly as in India. Of particular interest are innovations made in Pakistan's Punjab by Asif Sharif (FarmAll Technology, Lahore) to mechanize most aspects of SRI (http://sri.ciifad.cornell.edu/countries/pakistan/index.html#MSRI). Sharif is extending SRI principles also to other crops under this mechanized system, which he refers to as 'paradoxical agriculture,' *getting more production from reduced inputs*. This combines SRI principles with *conservation agriculture* (reduced or no tillage) and *organic agriculture* (to mobilize soil systems' productive potential more fully).

In Sharif's first MSRI trial in 2009, on a 20-acre field, an average yield of 13 t/ha was achieved, with 70% reduction in water and a similar reduction in labor requirements. While this methodology is not suitable for small farmers, mechanical construction of raised beds for no-till SRI for smallholders should be cost-effective. Sharif's work shows that SRI is not necessarily small-scale and labor-intensive, as detractors have often asserted. They are not aware of or up-to-date on the pluralism and dynamism of SRI as a system of ideas and insights, not being a standard kind of encapsulated technology.

4. Near East and North Africa: SRI merits are well-documented in **Iraq**, **Iran** and **Afghanistan**, thanks to the efforts of researchers at Al-Mishkhab Rice Research Station in Najaf and the Haraz Technology Center in Amol, and of Aga Khan Foundation staff working in Baghlan Province, respectively. These experiences are documented in the country pages on the SRI website. The Afghanistan experience is especially notable. Farmers at 1,700 m elevation, with a short growing season and political averaged yields of 9 tons/ha (http://sri.ciifad.cornell.edu/countries/afghanistan/AfgreportAKF_APMIS09.pdf).

The potential of SRI methods to raise yields even in **Egypt**, which has the world's highest current average rice yields, has been documented by Dr. Waled Elkhoby at the Sakha Research and Training Station (http://sri.ciifad.cornell.edu/countries/egypt/Egypt_Elkhoby_Report_2010.pdf). **Morocco** is the one country where SRI methods have been unsuccessful so far, apparently because of farmers' resistance to investing more labor in rice production and their lack of incentive to economize on water, even though water supply is limited.

5. Sub-Saharan Africa: SRI methods were evolved in **Madagascar** by Fr. Henri de Laulanié over half a lifetime living there, but spread has been slow. As many as 200,000 farmers may be using some or all of the recommended methods. A **Groupement SRI** has formed, supported by a **SRI Secretariat** with an effective website (http://groupementsrimada.org/en/?p=accueil). This work is assisted by the Better U Foundation, which has also funded a variety of local government and NGO initiatives.

One of the first countries where SRI was demonstrated was **The Gambia,** through initiative in 2000 by Dr. Mustafa Ceesay, now deputy director-general of the National Agricultural Research Institute (see Ceesay et al. 2006). The most impressive SRI initiatives have been in **Mali**, starting in the Timbuktu region, supported by the NGO **Africare** and the Better U Foundation. Farmers who are growing rice on the edge of the Sahara Desert have obtained averaged yields of 9 tons/ha (http://sri.ciifad.cornell.edu/countries/mali/MaliAfricare%2008and09.pdf). Now other donor agencies are getting involved in expanding SRI to other regions of Mali, with innovations including rainfed SRI and also SWI, the System of Wheat Intensification.

Other countries where the validity of SRI methods has been demonstrated include **Benin**, **Burkina Faso**, **Guinea**, **Mozambique**, **Senegal** and **Sierra Leone**, but there has not been follow-up. On the other hand, SRI is being more actively promoted in **Ghana**, **Zambia** and **Rwanda** (see report from IFAD: http://sri.ciifad.cornell.edu/countries/rwanda/RwandaIFADSRIflyerJan09.pdf). The status of all these different country experiences is reported on the SRI website.

This past year SRI has been introduced successfully in the Mwea irrigation scheme of **Kenya**, and prospects for fairly rapid expansion in that country are good. **Ethiopia** does not have much rice production, but SRI concepts are being applied in Tigray province to rainfed crops -- wheat, sorghum, millet, maize, and the preferred cereal crop *teff* -- by the NGO Institute for Sustainable Development (ISD). This extension of SRI methods is being referred to as **SCI**, the **system of crop intensification**. This parallels similar experimentation in India, particularly by the People's Science Institute in Himachal Pradesh and Uttarakhand. Because Africa has less irrigation development than most other parts of the world, this extrapolation and extension of SRI concepts may produce more benefits than SRI for rice.

6. Latin America and Caribbean: In this region, **Cuba** was the first country to begin evaluating and using SRI, thanks to the efforts of Dr. Rena Perez. The country was producing less than half of its rice consumption, and was financially constrained from utilizing petrochemical-based inputs. Yield increases of 50-100% are being achieved with reductions in water and other inputs. The productivity of SRI methods has been demonstrated on a small scale in **Brazil**, **Ecuador** and **Peru**, but no large-scale utilization yet.

A rice farmer in **Costa Rica**, Oscar Montero, adapted a Japanese mechanical transplanter to semi-mechanize SRI production in Guanacaste province, with a yield of 8 tons/ha. He is now working with a commercial company for expanding this methodology with equipment to Guatemala and El Salvador. SRI's productivity has recently been demonstrated by cooperative farms in **Panama** assisted by the NGO *Patronato de Nutriciòn*. Smallholders are getting a 50% increase in yields with reduced water, cost and labor, thanks to the initiative of Marie-Soleil Turmel, PhD candidate at McGill University, who is doing SRI agronomic research at the Tropical Research Institute of the Smithsonian Institution in that country.

The most recent country to 'join the SRI club' is **Haiti**, where Cornell with the support of the Better U Foundation is working with NGO partners and a USAID project. Farmer trials have shown the positive effects of SRI management on crop yields there. There is much potential for spread and impact of SRI in the Latin American and Caribbean region, but so far not much leadership has emerged within these countries. For all of the advantages that SRI's changes in management confer, replacement of present ways of thinking about and practicing rice cultivation does not occur automatically or easily. It takes persistence, patience, pressure and many other qualities, manifested in what we refer to as 'leadership,' to make changes occur. This has been the experience in India and many other countries.

III. EVOLUTION OF SRI

One of the most important aspects of the SRI experience has been its continuing evolution and change as the core concepts become better understood and demonstrated. It is important not to consider SRI as something static or limited. Three major expansions of SRI were noted in the introduction.

A. Rainfed SRI: As noted above, most of the SRI practice in Cambodia is under **upland conditions**, as irrigation development is limited there. This is true also in Myanmar, where more than 50,000 farmers, mostly ethnic minority and quite impoverished, have developed SRI for unirrigated production, with doubled yields (Kabir and Uphoff, 2007). In large areas of eastern India, the NGO PRADAN has been working with rainfed versions of SRI, having only the monsoon rains to provide water for the rice crop. Average yields of 7 tons/ha have been achieved in some areas without irrigation, showing that rice need not be treated as an irrigated crop.

B. Other Crops: This realization has led NGOs like the People's Science Institute in Dehradun and the Institute for Sustainable Development in Addis Ababa to begin working with SRI concepts and methods to adapt these to other crops, not relying on irrigation facilities. SWI with **wheat** is now becoming an established alternative management system, with positive results in Bihar, Madhya Pradesh, Himachal Pradesh and Uttarakhand (Prasad 2008; Bhalla 2010). A version of SRI adapted to **sugar cane** under the rubric of Sustainable Sugarcane Initiative has begun spreading since launched in 2009 by WWF and ICRISAT (see their manual at http://assets.panda.org/downloads/ssi_manual.pdf). There is even a report of 'brinjal SRI' from Orissa state (Das 2010).

Of particular interest should be 'the other SRI,' the system of *ragi* intensification. This has been validated in Uttarakhand, Bihar, Karnataka and other states of India (Madhavan 2010). Given the large number of poor households in dryland areas who depend upon *ragi* (finger millet) for their subsistence, and the high probability that other cereal crops such as pearl millet and sorghum would also respond positively to SRI concepts and practices, ***priority should be given to research on extending SRI ideas to millet and other crops.*** SRI methods have been able to give 3-5 fold increases in the yield of ***teff***, the preferred but low-yielding cereal in Ethiopia (http://sri.ciifad.cornell.edu/aboutsri/othercrops/teff/index.html). So one of the most important things that could be done to improve the lives of food-insecure households in India would be a national initiative to undertake research and extension on ***SRI for millets***.

C. Mechanization: Although SRI was initially considered to be a labor-intensive innovation – and it was dismissed by some skeptics as for this reason – experience has shown that this is usually a transitory problem. Farmers often even find SRI methods to be **labor-saving** once they have acquired confidence and skill. As early as 2004, evaluations in India by TNAU and IWMI-India found SRI to be reducing labor requirements per hectare by 8% (Sinha and Talati 2007). But even this assessment has become dated as farmers in various countries have been figuring out how to mechanize transplanting, weeding and other operations to reduce SRI's labor requirements. The Pakistan example cited above is the most ambitious effort in this direction, but others have been reported and will keep coming in the years ahead.

D. Climate Change: Farmers in most countries in the decades ahead will have to cope with a more capricious and unpredictable climate which will make 'extreme events' -- droughts, flooding, cold snaps, heat spells, with often accompanying increases in pest and disease problems – more frequent, and more extreme. One of the most attractive features of SRI, although not well or systematically documented, is the ability of its phenotypes to be more resistant or more tolerant to adverse climatic conditions, to abiotic and biotic stresses.

India experienced severe problems of **drought** in many parts of the country in 2009. The Minister of Agriculture for Tamil Nadu has credited the spread of SRI methods in his state with enabling its farmers to raise their paddy production in 2009 despite a reduction in acreage forced by the adverse weather (http://www.hindu.com/2009/12/01/stories/2009120155040500.htm).

In China, a promising adaptation of SRI concepts has been to combine plastic mulch with no-till, raised-beds rice production. This conserves soil moisture and suppresses weeds, raising yields and profitability, even in drought years (http://sri.ciifad.cornell.edu/countries/china/ChinaSichuanDroughtResist09.pdf). Given the increasing stress on crop production coming from climate change, these opportunities to protect and buffer crops against extremes (high and low) of temperature and precipitation should be pursued as a priority.

IV. LEARNING

The main learning from SRI experience has been that **changes in management practices** can raise productivity as much as, or even more than, changes in genetic potential, although these are not competing methods since one always wants to use the best management practices with the best genetic material. There are many such changes already available, not requiring much expenditure.

We have also learned that **farmer participation** in the process of technological development is very beneficial and cost-effective, with researchers and extensionists interacting with farmers in what Merrill-Sands and Kaimowitz (1992) called 'the triangular model' for agricultural development, or what ILEIA refers to as 'participatory technology development.'

A third conclusion is, as noted above, that **SRI is changing and improving** season by season. It was premature for skeptics and critics to try to assess, and then to dismiss, the initial, 'classic' version of SRI developed by Fr. Laulanié, when they first learned about it. Their early rejection of SRI will probably come to be seen as an unfortunate misuse of 'scientific' reasoning and methodology. From what we are learning from SRI and its various extensions, noted in the preceding section, it appears likely that SRI will contribute to a significant and beneficial ***paradigm shift*** for the agricultural sector that will better situate it to meet the emerging needs, challenges and constraints of the 21st century (Uphoff 2007).

Looking into the Future

My own estimate is that we are only about one-third of the way along the 'path' that SRI has opened for the agricultural sector. One of foreseeable convergence for SRI is with **conservation agriculture** (CA) (http://www.fao.org/ag/ca/). This is an alternative farming system that combines *zero-tillage* with continuous *ground cover* and *crop rotation*. By reducing soil disturbance and enhancing soil organic matter, CA improves soil fertility, as it also reduces inputs and costs of production. SRI and SCI practiced on *raised beds* with mulch or other cover and with rotated crops, e.g., with potatoes or mushrooms as practiced by SRI farmers in Vietnam and China, is a promising direction for SRI's evolution. This can be, but need not be, labor-intensive as seen from the innovations in Pakistan noted above.

Given the attractiveness of SRI benefits and the urgency of reducing crop water demands, it may be tempting for governments, and even NGOs, to promote SRI through *top-down methods*, as the Green Revolution technologies were promulgated. It is my hope that the *participatory strategies* that have evolved for SRI extension so far, such as farmer-to-farmer networks and farmer field schools, will be favored and utilized. It is worth noting that the NGO which Fr. Laulanié and his Malagasy colleagues established was called named *Association Tefy Saina*. This does not mean 'to improve rice production' but rather 'to improve the mind.'

SRI as a Different Kind of Innovation

SRI is **a hybrid mental-material innovation** in which the human factor is as important as its biophysical elements. Given its nature, SRI extension should, in my view, continue to be a collaborative effort across all sectors: governmental, non-governmental, and private. In practically all the countries where SRI has become an effective influence, this has been based on **multi-sectoral collaboration** across many kinds of institutions: government agencies, NGOs, universities, research institutions, private companies, foundations, banks, and others, with strong connections to community organizations and partners.

The motive force for SRI has not really been organizations as such, but instead **like-minded and effective individuals** within these organizations, from the national to the community level, who have understood *the potentials and the mechanisms* of SRI, and who have done the requisite strategizing and planning, the necessary resource mobilization, the adept and persistent implementation, and the critical thinking and evaluation that have kept the SRI enterprise moving and improving. The consortia that have moved SRI forward have been often formal but more often informal, and in almost all instances very egalitarian.

The original and continuing objectives of SRI are three-fold: (i) to assist **farmers** and their households through higher productivity, resource saving, and environmental buffering; (ii) to benefit **consumers** with food that is lower priced and higher quality, better for their health; and (iii) to conserve the **environment**, enhancing soil and water quality and conserving biodiversity. This constitutes a very ambitious agenda, but the needs of the 21st century demand this much and more. Thanks to the efforts of a growing number of persons from all walks of life and of institutions around the world, the feasibility of such multi-functional agriculture is becoming more and more evident.

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